STRENGTHENING HEALTH SYSTEM AND COMMUNITY RESPONSES TO CONFRONT COVID-19 PANDEMIC IN RESOURCE-SCARE SETTINGS

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STRENGTHENING HEALTH SYSTEM AND COMMUNITY RESPONSES TO CONFRONT COVID-19 PANDEMIC IN RESOURCE-SCARE SETTINGS

Topic Editors:
Bach Tran, Hanoi Medical University, Vietnam
Jongnam Hwang, University of Connecticut, United States
Thi H. Do, Nguyen Tat Thanh University, Vietnam

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EDITORIAL
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Editorial: Strengthening Health System and Community Responses to Confront COVID-19 Pandemic in Resource-Scare Settings

Bach Xuan Tran[1]*, *Linh My Tran*[2], *Jongnam Hwang*[3], *Hoa Do*[4] and *Roger Ho*[5]

[1] Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] Institute of Health Economics and Technology (iHEAT), Hanoi, Vietnam, [3] Division of Social Welfare & Health Administration, Wonkwang University, Iksan, South Korea, [4] Center of Excellence in Public Health Nutrition, Nguyen Tat Thanh University, Hanoi, Vietnam, [5] Department of Psychological Medicine, National University of Singapore, Singapore, Singapore

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Editorial on the Research Topic

Strengthening Health System and Community Responses to Confront COVID-19 Pandemic in Resource-Scare Settings

The COVID-19 pandemic has substantially affected global communities and health systems in both high- and low-income countries. Many nations have been experiencing very high population burdens that implies the importance of strengthening responses systems and mobilizing communities in pandemic preparedness and control. The shortage of resources in LMICs is well-documented prior to COVID-19 and it has been worsened with the surge of COVID-19. In many LMICs, testing capacity remains inadequate, the number of ICU beds is far less than required, access to drug treatments such as dexamethasone is limited, and the supply of therapeutic oxygen and ventilators is insufficient (1). The scarcity is caused by various factors including the migration to developed countries, shortage of supplies, poor healthcare infrastructure, limited ICU facilities, and lack of access to guidelines and protocols (2). Important difficulties that LMICs are facing are the insufficient testing capacity and the shortage of healthcare providers, which precluded accurate assessment of disease burden and subsequently resource allocations (2). This Research Topic summarizes experience of low- and middle-income countries (LMICs) in managing both the epidemiological transition and the threat of emerging infectious diseases. It offers the ideal opportunity at this critical juncture in the development of global health to identify key lessons for health system strengthening in LMICs.

The following studies summarized experience of LMICs in managing the surge of COVID-19 in terms of capacities and responsiveness of health systems and communities. Zhang studied the experience of public health system construction in China's COVID-19 prevention and identified key lessons for other countries to confront unprecedented pandemic. The paper not only pointed out several advantages of China's public health system construction in response to COVID-19, such as adequate supply of health resources and improved affordability of health care, but also discussed China's deficiencies, including low utilization efficiency of health resources, unequal ability to pay for medical expenses, and late disclosure of virus information in the early stage of the outbreak of COVID-19. Given that Nepal is facing a flood of COVID-19 cases after the lockdown was lifted in July 2020, Rayamajhee et al. provided critical insights on response of the government, highlighting the need to increase testing, tracing, and isolation capacity, and to set up quality quarantine centers throughout the nation to address the rise in COVID-19 infection cases. As cases have continued to fluctuate over a year into the pandemic in Indonesia, Mahendradhata et al.

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Edited by:
Hongbao Cao,
George Mason University,
United States

Reviewed by:
Qi Zhang,
National Institutes of Health (NIH),
United States
Piao Hu,
The Catholic University of America,
United States

***Correspondence:**
Bach Xuan Tran
bach.khcn@gmail.com

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reviewed the current capacity of the healthcare system to respond to COVID-19 and emphasized the need for the Indonesian Government to ramp up the country's healthcare capacity in order to absorb and accommodate the varying healthcare demands during the pandemic. Saha and Gulshan provided a systematic analysis of the overall patterns in terms of number of cases, number of deaths, and impacts of COVID-19 in Bangladesh. The authors also shed light on the underlying causes that resulted in a continuous outbreak while discussing possible measures, effectiveness of the preparedness, implementation gaps, and their consequences to gather vital information and prevent future pandemics. Abd El Ghaffar et al. investigated the situation in some of the COVID-19 screening hospitals in Egypt in terms of inpatient beds, ICU beds, and ventilator utilization rates. Results from this paper, which indicated a shortage of resources, would help policymakers make informed resource reallocation decisions in Egypt, or other developing countries, which suffered from a lack of resources and a weak health system prior to the pandemic. Coumare et al. discussed the challenges and experiences in preparation and responses to the ongoing COVID-19 pandemic at a tertiary teaching hospital situated at Puducherry, India. Tran et al. examined factors associated with the intention to participate in COVID-19 frontline prevention activities among Vietnamese nursing students. The finding suggested that socioeconomic characteristics of participants, their source of COVID-19 related knowledge, and their perception and attitude toward participating in COVID-19 frontline activities were associated with intention to participate. Given resource-scarce settings of most LMICs, these countries are challenged by their limited capacity for manufacturing test kits, limited budgets for equipment and reagents, and scant ability to make competitive bids for global supplies. Gyawali and Mohammad Al-Amin et al. advocated for recognition of the almost insurmountable obstacles that face the implementation of non-pharmaceutical interventions for COVID-19 management in Asian LMICs and called for a global commitment to the equitable distribution of therapeutants and vaccines. Although the World Bank is making available more than $160 billion funding to LMICs to purchase and distribute COVID-19 vaccines, tests and treatment and mitigate the health, economic, and social shocks, and philanthropic organizations such as the Global Alliance for Vaccines (GAVI) have received billions of dollars in donations, much more will be required for LMICs to combat COVID-19 and mitigate the expected economic downturn. In the long term, LMICs will need to develop their own capacity to manufacture and distribute vaccines, as well as strengthen primary health centers to manage the impact of the pandemic.

In addition to capacities and responsiveness of health systems and communities to respond to the pandemic, numerous studies have highlighted the importance of strategic planning and resource mobilization to maintain essential health services and maximize human resource capacity to address COVID-19 situation and its associated disruptions. Muhammad Nur Amir et al.. described the workforce mobilization from the National Institutes of Health (NIH) to the other public healthcare facilities within the Ministry of Health (MOH) in the early phases of the COVID-19 pandemic management in Malaysia. The paper demonstrated how this workforce mobilization team efficiently mobilize the healthcare workforce and fulfill requests received for human resource aid, resulting in reduced infected COVID-19 cases throughout the country. Nguyen D. N. et al. provided evidence for reforming the training programs to prepare medical students, a potential task force with the capability to support the stretched health sector, for COVID-19 responses in Vietnam. This study suggested that the training curriculum should include both theoretical approaches (e.g., pathology and critical treatments) as well as other contextual approaches to achieve efficient epidemic control in specific regions. Le et al. illustrated the potential and feasibility of intersectoral collaboration in epidemic preparedness and response at grassroots levels in the threat of COVID-19 pandemic in Vietnam, which ensures sufficient resources for urgent cases and helps to inform a determined response framework.

Given the speed and spread of transmission of COVID-19, assessing the effectiveness of epidemiological monitoring and surveillance of the epidemics is critical to control the expansion of the epidemics and avoid the collapse of health care systems. Shewade et al. reported that the estimated COVID-19 deaths in India after adjusting for the coverage and quality of the routine death surveillance may be 5.5–11 times the reported COVID-19 deaths. Hence, this study further discussed the routine deaths surveillance in India, the rationale for adjusting the reported COVID-19 deaths for coverage of the routine death surveillance and its implications on the estimated infection fatality ratio (IFR) for India in order to make meaningful and reliable comparisons. Mansab et al. highlighted the disparity in oxygen provision for COVID-19 patients between 26 nations included in the study and suggested that there was an association with higher national mortality rates in those nations that pursued a conservative oxygen strategy. Abbasi-Kangevari et al. sought to determine the priorities of the Iranian public toward the fair allocation of ventilators during the COVID-19 pandemic. Participants stated that socioeconomic factors, except for age > 80, should not be involved in prioritizing mechanical ventilators at the time of resources scarcity. Front-line physicians and nurses of COVID-19 patients, pregnant mothers, mothers who had children under 2 years old had been given high priority.

Many articles in this Topic focused on evaluating the effectiveness of epidemiological, psychosocial and economical interventions to prevent the importation, spreading and relieve the impact of COVID-19 pandemic in LMICs. Vietnam has achieved initial results in flattening the curve and slowing the spread of COVID-19 transmission in the community, which is attributable to a high-level adherence with social distancing measures, accompanied with contact tracing, mass testing, and mandatory isolation. Vo et al. demonstrated how social distancing measure had been implemented in Vietnam and further discussed factors associated with the high compliance of Vietnamese with social distancing measures. Tam et al. discussed the evidence on the effectiveness, and rationale for community mass masking to prevent the COVID-19 transmission in Vietnam. Sun et al. showed that the proper management of inbound travelers from outbreak areas had a significantly positive effect on the prevention and control of the virus and

suggested that effective measures taken by Yunnan province may provide an important reference for preventing the COVID-19 outbreak in other regions. As the prevalence of psychological stress among healthcare workers (HCWs) in Vietnam during the COVID-19 pandemic was high, Nguyen P. T. L. et al. sought to understand COVID-19-related, psychological stress risk factors among HCWs, their concerns and demands for mental health support during the pandemic period. The author recommended psychological interventions involving web-based consulting services to provide mental health support among HCWs. Nguyen A. N. et al. assessed the knowledge and practices regarding the prevention of the COVID-19 among the HCWs in Vietnam to identify the ways of disseminating information to maximize the safety of these essential workers. Findings from this study suggested that future education initiatives should centre initially on the COVID-19 virus aerosols with the primary focus on doctors, especially those in emergency and the intensive care departments. In addition to epidemiological and psychosocial interventions, Nguyen H. T. T. et al. described economic recovery solutions implemented by the Vietnam government to manage the fiscal deficit, such as focus on effectively implementing domestic stimulus, use the savings from falling international oil prices to curb the crisis, earn funding from the World Bank WB and the International Monetary Fund, etc.

Several studies have raised important points regarding the impact of perceptions and attitudes toward the COVID-19 crisis on the improvement of both public health and individual well-being and highlighted how digital health care and social media may influence public's attitude during the COVID-19 outbreak. Specifically, Klement pointed out that journalism, politics, and medicine involved within the COVID-19 crisis have maintained a simple narrative and reductionist thinking and emphasized the need for systems thinking during the outbreak. A survey by Raza et al. was conducted to understand knowledge, attitudes, and practices related to COVID-19 among the students in Lahore, Pakistan. This survey showed that most of the students were well informed about COVID-19 and exhibited a proactive approach during the outbreak, suggesting an effective public health campaign of the local government to deliver public health knowledge in the community. Chatterjee et al. focused on highlighting some of the key aspects of digital healthcare during the times of COVID-19 pandemic in South America. This study shed light on the role of Artificial Intelligence and the Internet of Things role in resource optimization along their potential applications like clinical decision support systems and predictive risk modeling, especially in the direction of combating the emergent challenges due to the COVID-19 pandemic. Mat Dawi et al. examined the influence of e-government and social media on the public's attitude to adopt protective behavior and suggested that during the COVID-19 outbreak, public health decision makers may use e-government and social media platforms as effective tools to improve public engagement on protective behavior. Although Nguyen, Nguyen, Le, et al. demonstrated a high level of agreement among the general population toward the importance and necessity of national response measures to combat the COVID-19 epidemic in Vietnam, Nguyen, Nguyen, Nguyen, et al. expressed concern about the impact of fake news on the adherence of national response measures during the lockdown period in Vietnam. In response to fake news, the government had made early predictions and concrete strategies, such as passing a cybersecurity law or establishing official communication channels, which may also have important lessons for other nations in the fight against COVID-19.

Besides efforts to mitigate pandemics in LMICs from medical staff training and monitoring to system modernization, it is also important to consider potential barriers that arise during the COVID-19 vaccine rollout in LMICs and how to address these difficulties in resource-scarce settings. Recent studies have reported several challenges for vaccination faced by LMICs, including vaccine hesitancy (3), inadequate cold-chain and storage (3), low resource availability (4), poor roads to transport vaccines (5), lack of coordination (7), and limited funds for surveillance (6, 7). These issues could be partially addressed from strategies discussed in this topic, such as expanding healthcare workforce capacity to increase vaccination speed, and improving the population willingness to vaccinate. For example, several articles have described strategies to maximize human resource capacity to address COVID-19 situation and pointed out the need to improve healthcare capacity in order to accommodate the varying healthcare demands during the pandemic (Gyawali and Mohammad Al-Amin et al.; Mahendradhata et al.; Rayamajhee et al.; Tran et al.; Zhang). Ensuring sufficient healthcare workforce, training more health providers, and recruiting volunteers would help to increase vaccine availability, distribution, and monitoring. In addition to healthcare workforce capacity, vaccine acceptance and hesitancy remain a significant barrier to increase vaccination rate. Perceptions and attitudes play an important role on the improvement of both public health and individual well-being, which significantly influenced by Internet and social media (Chatterjee et al.; Klement; Mat Dawi et al.; Nguyen, Nguyen, Le, et al.; Nguyen, Nguyen, Nguyen, et al.; Raza et al.). Thus, governments could establish awareness-building initiatives using community and mass media to manage inaccurate information about vaccines, lack of information, and lack of trust in the government and pharmaceutical companies. Lastly, governments should consider to increase budgets for COVID-19 vaccine purchase and delivery to scale up COVID-19 vaccination and offer access to all populations; however, this has not been discussed in the collection of papers in this topic.

The COVID-19 pandemic has challenged the healthcare capacity of many countries. The collection of papers in this topic provides insight on the opportunities and challenges in strengthening health system and community responses to confront COVID-19 pandemic in resource-scarce settings. Lessons learned in terms of strength and limitations from the latest evidence on health sectors and community responses to control the COVID-19 pandemic in LMICs would suggest implications to improve the effectiveness of current policies and facilitate development of new strategies to strengthen the capacity and efficiency of healthcare systems in the fight against COVID-19. Governments will continue to play an important role in responding to the coronavirus pandemic and providing access to care for communities in resource-constrained countries with

limited human, infrastructural, and financial resources and that are behind the curve in the spread of the pandemic.

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All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

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REFERENCES

1. Alhalaseh YN, Elshabrawy HA, Erashdi M, Shahait M, Abu-Humdan AM, Al-Hussaini M. Allocation of the "already" limited medical resources amid the COVID-19 Pandemic, an iterative ethical encounter including suggested solutions from a real life encounter. *Front Med.* (2021) 7:616277. doi: 10.3389/fmed.2020.616277
2. Phua J, Faruq MO, Kulkarni AP, Redjeki IS, Detleuxay K, Mendsaikhan N. Critical care bed capacity in Asian countries and regions. *Crit Care Med.* (2020) 48:654–62. doi: 10.1097/CCM.0000000000004222
3. Phillips DE, Dieleman JL, Lim SS, Shearer J. Determinants of effective vaccine coverage in low and middle-income countries: a systematic review and interpretive synthesis. *BMC Health Serv Res.* (2017) 17:681. doi: 10.1186/s12913-017-2626-0
4. LaFond A, Kanagat N, Steinglass R, Fields R, Sequeira J, Mookherji S. Drivers of routine immunization coverage improvement in Africa: findings from district-level case studies. *Health Policy Plan.* (2015) 30:298–308. doi: 10.1093/heapol/czu011
5. WHO. *Global Vaccine Action Plan-Monitoring, Evaluation and Accountability—Secretariat Annual Report 2015*. (2015). Available online at: http://www.who.int/immunization/global_vaccine_action_plan/gvap_secretariat_report_2015.pdf?ua=1 (accessed March 20, 2021).
6. Nelson KN, Wallace AS, Sodha S V, Daniels D, Dietz V. Assessing strategies for increasing urban routine immunization coverage of childhood vaccines in low and middle-income countries: a systematic review of peer-reviewed literature. *Vaccine.* (2016) 34:5495–503. doi: 10.1016/j.vaccine.2016.09.038
7. Guignard A, Praet N, Jusot V, Bakker M, Baril L. Introducing new vaccines in low- and middle-income countries: challenges and approaches. *Expert Rev Vaccines.* (2019) 18:119–31. doi: 10.1080/14760584.2019.1574224

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Fake News Affecting the Adherence of National Response Measures During the COVID-19 Lockdown Period: The Experience of Vietnam

Thao Thi Phuong Nguyen[1], Duy Cao Nguyen[1], Anh Trong Tung Nguyen[2], Long Hoang Nguyen[1], Giang Thu Vu[3], Cuong Tat Nguyen[4,5], Trang Ha Nguyen[4,5] and Huong Thi Le[1]*

[1] Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] Institute of Health Economics and Technology, Hanoi, Vietnam, [3] Center of Excellence in Evidence-Based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam, [4] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [5] Faculty of Medicine, Duy Tan University, Da Nang, Vietnam

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Edited by:
Jongnam Hwang, Wonkwang University, South Korea

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Simon Grima, University of Malta, Malta
Minh V. Nong, Hospital for Tropical Diseases (HTD), Vietnam

***Correspondence:**
Cuong Tat Nguyen
nguyentatcuong@duytan.edu.vn

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COVID-19 has severely affected people's health and well-being, including all economic sectors, tourism, culture, and education. Along with combating the COVID-19 epidemic, fighting the "infodemic," which refers to the rapid spread of misinformation, related to the disease on the social media is also of concern, because fake news spreads faster and easier than this virus, and just as dangerous (1). This causes anxiety among public and motivate them to follow or believe in the unreliable information, making the containment of epidemic more complicated when raising the uncertainty and unnecessary behavior of public, and hindering the collaboration and unity in combating the epidemic (2).

In Vietnam, the role of press and social media in spreading the government's information regarding COVID-19 pandemic is undeniable; however, fake news phenomenon is still substantial. A report of the Ministry of Information and Communications revealed that from 01/02 to 05/31/2020, the press had published a total of 560,048 news and articles about COVID-19 translation. According to the statistics of the police force, from the onset of the Covid-19 epidemic to the middle of March 2020, there were nearly 300,000 news articles on cyberspace, posts on websites, blogs, forums, and almost 600,000 news, articles, videos and clips related to the disease posted on social networks (3). When Vietnam entered a "new normal" state after April 17, the rate of news articles related to the COVID-19 epidemic was still maintained by media and radio agencies around 28–40% of news and articles on recovery, economic development but not subjective in disease prevention (3). In the first 5 months of 2020, there have been nearly 17 million mentions in the Vietnamese cyberspace (status lines, comments) related to the COVID-19 epidemic situation in Vietnam (3). However, all of these swift measures were not enough to regain the public's trust and stop the rapid spreading of fake news through the population. There were various news, articles with unverified, distorted, false content that attracted millions of comments and shares. Security authorities have verified and treated 654 cases of reporting fake news, sanctioned administratively more than 146 people (4). Cyberspace is a favorable environment for fake news given that 64 million Vietnamese are Internet users, as well as 58 million people have at least one social network site account (e.g., Facebook, Instagram, or Zalo) (5).

Massive media bombardment regarding the lockdown period led to public speculation in Vietnam, as in many parts of the world, which was the cause of grocery shortages and great consequences. Supermarkets and grocery stores revealed out-of-stock of antibacterial gels, antibacterial wipes, detergents, and toilet paper, while pharmacy stores reported the shortage of

isopropyl alcohol, latex gloves, and medical-grade masks (6), leading to the deficiency of personal protective equipment in hospital settings, including sites designated by the MoH as COVID-19 response sites (7). Increasing fake news regarding alternative COVID-19 treatments has led people to storm pharmacies and buy stocks of available drugs such as hydroxychloroquine (8); consequently, many patients with systemic lupus erythematosus (SLE) and rheumatoid arthritis (RA) cannot access their treatment because of nationwide shortages. Given that self-medication is common among the Vietnamese due to the lack of governmental regulation about drug use, these drugs are uncontrolledly purchased and used without a prescription, which increase the risk of hospitalization due to drug misuse (9). Moreover, spreading fake information on the number of confirmed cases and fatal cases in Vietnam led to the public's anxiety and stress. Some false information about border closure with China, calling on Vietnam to close the border, calling for people to go on strikes throughout the territory of Vietnam, or disseminating misinformation about the vaccine against Coronavirus affects significantly destabilizing security and politics in Vietnam (5). Fake news affected sharply to stigma among unskilled labor groups and their family in ethnic minority groups. Lack of COVID 19 epidemic knowledge and fear of stigma (include their family was attacked and alienated by false information) that commenced to evading health declaration procedure. In consequence, increasing the number of unconfirmed COVID-19 cases will become dangerous spreading sources for their ethnic minority groups in particular and all community in general (10).

In response to fake news, especially during the COVID-19 pandemic, the government has made early predictions and concrete strategies. Since June 12, 2018, the National Assembly of Vietnam passed a cybersecurity law comprising seven chapters and 43 articles that stipulated activities to protect national security, ensure social order and safety on cyberspace, and responsibilities of agencies, organizations, and individuals involved (11). Cybersecurity law made it easier for the government to handle violations of organizations and individuals on cyber such as posting and spreading fake news. As a result, over the past time, according to the Vietnamese Ministry of Public Security statistics, the police force has made a list of hundreds of objects, convened, fought nearly 200 cases, and administratively handled more than 30 cases of spreading fake information of COVID-19 epidemic (3). Secondly, the government has now established official communication channels on social networking sites such as the Government Information page on Facebook or the official page of the Ministry of Health on Zalo—one of the most popular social applications in Vietnam. Besides, ministries and departments have directly sent messages to people's contact phone numbers to provide information about the epidemic, which was never implemented before. This solution helps all Vietnamese people who do not have the opportunity to access the internet to capture information in time about the pandemic, thereby distinguishing fake and accurate news. In ethnic minority groups, local authorities enhanced advocacy on prevention measures, increasing knowledge of the COVID 19 epidemic, avoiding stigma COVID 19 patients and their family (10). Finally, accompanying the people in preventing and eliminating false information on cyberspace, the investigating police agency has intensified the review, discovered, and promptly sanctioned cases of giving incorrect information for profiteering purposes or confusing public opinion.

Moreover, the government needs to pledge to be transparent in providing information, helping people grasp promptly and take measures to prevent and fight epidemics. Solving this method also helps people have faith in the official news of the state. However, the most important thing is that every internet user needs to be alerted to select reliable information and respect seriously for Vietnamese law. Furthermore, health professionals and health workers should regularly transfer necessary knowledge about disease prevention and control to people on the social network.

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REFERENCES

1. Ghebreyesus TA. *Munich Security Conference*. World Health Organization (WHO) (2020). Available online at: https://www.who.int/dg/speeches/detail/munich-security-conference (accessed July 29, 2020).
2. Hao K, Basu T. The coronavirus is the first true social-media "Infodemic". *MIT Technology Review* (2020).
3. *Preliminary Conference on Preliminary Review of Information and Propaganda on Prevention and Control of COVID-19*. Ministry of Health (2020). Available online at: https://moh.gov.vn/tin-noi-bat/-/asset_publisher/3Yst7YhbkA5j/content/hoi-nghi-so-ket-so-ket-cong-tac-thong-tin-tuyen-truyen-ve-phong-chong-dich-covid-19 (accessed July 31, 2020).
4. Trong D. More than 654 people were treated for posting false information about COVID-19. *Tuoi Tre*. (2020). Available online at: https://tuoitre.vn/hon-654-nguoi-bi-xu-ly-vi-dang-tin-that-thiet-ve-covid-19-20200315095026411.ht (accessed July 29, 2020).
5. Hong C. *Fake News Raged Between the Heart of the COVID-19 Epidemic*. Vietnam People's Public Security (2020). Available online at: http://cand.com.vn/Van-de-hom-nay-thoi-su/Virus-tin-gia-tren-khong-gian-mang-Tin-gia-hoanh-hanh-giua-tam-dich-COVID-19-583683/ (accessed July 29, 2020).
6. Tien X. Medical masks in Danang are scarce after suspected COVID-19 cases of infection in 2020. *VTC News*. (2020). Available online at: https://vtc.vn/khau-trang-y-te-o-da-nang-khan-hiem-sau-ca-nghi-nhiem-covid-19-ar559550.html (accessed July 29, 2020).

7. Ngoc K. Hospitals lack masks, doctors self-sew. *24H Newpapers*. (2020). Available online at: https://www.24h.com.vn/tin-tuc-trong-ngay/cac-benh-vien-thieu-khau-trang-bac-si-tu-may-c46a1123923.html (accessed July 29, 2020).
8. Linh T. Scandal of data on antimalarial drugs for treatment of Covid-19. *VN Express*. (2020). Available online at: https://vnexpress.net/be-boi-du-lieu-thuoc-sot-ret-dieu-tri-covid-19-4113347.html (accessed July 29, 2020).
9. *Hospitalized for Listening to "Social Networks" Taking Antimalarial Drugs Against Covid-19*. Hoa Binh Radio and Television Station (2020). Available online at: http://hoabinhtv.vn/suc-khoe-doi-song/nhap-vien-vi-nghe-mang-xa-hoi-uong-thuoc-sot-ret-chong-covid-19 (accessed July 31, 2020).
10. *Covid-19 Epidemic Prevention in Ethnic Minority and Mountainous Areas: Ethnicity and Development*. (2020). Available online at: https://baodantoc.vn/phong-chong-dich-covid-19-o-vung-dtts-va-mien-nui-lan-toa-nhung-nghia-tinh-1587607445891.htm (accessed April 23, 2020).
11. *Cyber Security Law*. National Assembly of the Socialist Republic of Vietnam (2018). Available online at: https://thuvienphapluat.vn/van-ban/cong-nghe-thong-tin/Luat-an-ninh-mang-2018-351416.aspx?fbclid=IwAR0mb9qn3e (accessed July 29, 2020).

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Perceptions and Attitudes Toward COVID-19-Related National Response Measures of Vietnamese: Implications for Pandemic Prevention and Control

Thao Thi Phuong Nguyen[1], Long Hoang Nguyen[1], Huong Thi Le[1], Giang Thu Vu[2], Men Thi Hoang[3,4], Diep Ngoc Nguyen[3,4], Xuan Thi Thanh Le[1], Bach Xuan Tran[1,5], Thao Thanh Nguyen[1], Quan Thi Pham[1], Nhung Thi Kim Ta[1], Quynh Thi Nguyen[1], Carl A. Latkin[5], Roger C. M. Ho[6,7] and Cyrus S. H. Ho[8]*

[1] Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] Center of Excellence in Evidence-Based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam, [3] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [4] Faculty of Pharmacy, Duy Tan University, Da Nang, Vietnam, [5] Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, United States, [6] Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore, [7] Institute for Health Innovation and Technology (iHealthtech), National University of Singapore, Singapore, Singapore, [8] Department of Psychological Medicine, National University Hospital, Singapore, Singapore

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***Correspondence:**
Men Thi Hoang
hoangthimen@duytan.edu.vn

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Introduction: Public perceptions and attitudes toward preventive and control measures are vital to ensure the success of national response strategies in combating COVID-19. This study assessed perceptions and attitudes via the importance of national response measures to COVID-19 among people under the nationwide partial lockdown of Vietnam.

Methods: An online cross-sectional survey was conducted on 1382 people in Vietnam mainly public administration and health workers with relatives. Perceptions and attitudes toward seven national response measures to COVID-19 epidemics were assessed. Multivariable Tobit regression models were employed to identify factors associated with the perceptions.

Results: The proportion of participants strongly agreeing with the measure "Isolate people from abroad and people in contact with people infected with COVID 19" was the highest (96.9%), following by the measure "Obligatory to wear face masks in public places" (96.8%), and "Blockade of places having new cases" (92.9%). Living in the Southern region, having a family with more than 5 people, and having post-graduate education were negatively correlated to the levels of perceived importance of "Social distancing and community screening" measures. Meanwhile, having post-graduate education (Coef. = −0.04; 95%CI: −0.07; −0.01), working as white-collar workers (Coef. = −0.04; 95%CI: −0.08; −0.01), and having fixed-term, full-time employment (Coef. = −0.07; 95%CI: −0.10; −0.03) were inversely associated with the levels of perceived importance of the "Mandatory quarantine and personal protective equipment" measures.

Conclusion: This study informed highly positive perceptions and attitudes toward the national response measure to combat the COVID-19 in Vietnam. Contextualized strategies to maintain and improve these perceptions are warranted to ensure the success of preventive measures in the future.

Keywords: COVID-19, attitudes, perceptions, lockdown, Vietnam

INTRODUCTION

COVID-19 pandemic has demonstrated its social, health, and economic devastations worldwide (1, 2). Until 19 July 2020, more than 14 million people in 216 countries and territories acquired severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), a cause of COVID-19, and approximately 600,000 COVID-19-related deaths are recorded (3). National lockdowns and other preventive measures such as social distancing, strict quarantine, contact tracing, or personal protective gear (e.g., face masks) promotion have been implemented across countries to control the source of infection, cut off the transmission route and mitigate the damage of the pandemic (4–6). Some initial progress has been achieved (3); however, many countries are still facing the risk of a recurring epidemic (7). Therefore, unless vaccines for this disease are available, these preventive measures continuously play an essential role in preventing the transmission in all nations (8).

Previous experiences indicated that the success of national response strategies heavily relied on the public's perceptions and attitudes toward the risk of an epidemic and the importance of preventive measures (9, 10). They have a major role in forming individuals' self-protection behaviors (11, 12), willingness to cooperate, and adopt new preventive measures during outbreaks (11–18). Lessons learned from the Severe acute respiratory syndrome (SARS) pandemic in 2003 showed the association between panic emotion and attitudes toward infectious diseases and preventive measures, which negatively affected the efforts to prevent the infectious transmission (9, 10). Prior literature also highlighted that the community's perceptions and attitudes were strongly related to the compliance toward preventive measures (19). Thus, assessing perceptions and attitudes toward national COVID-19 preventive measures are vital to understanding the sustainability of these strategies in the coming epidemics.

As being considered among countries with the highest risk of the COVID-19 pandemic, Vietnam has also implemented such preventive measures to combat the pandemic from very early phase (20). After detecting the first 16 positive cases, the Vietnam Government decided to tighten borders with China, revoked aviation licenses and restricted visas, warned citizens to avoid epidemic areas (21, 22), closure of all educational facilities (23), and call self-protective implementation (e.g., using facemasks, washing hands, and seeking medical care if getting symptoms) (24). From 7 March 2020, the Vietnamese Government decided 14-day compulsory quarantines for Vietnamese people returning from abroad, temporarily suspended visas for foreigners coming to Vietnam (25), and requested that people in the community report Covid-19 related health conditions (26). Moreover, closing all public areas except for essential facilities as well as bans and restrictions on public transport were implemented (27). On 1 April 2020, the 15-day national lockdown was performed as a strong response to prevent disease and reduce the transmission (28). With these strict measures, as a result, to date, only 332 positive cases were reported without any deaths (29), which has been much lower than other countries with similar population size (3).

Given the matter that Vietnam is still at risk of recurring COVID-19 pandemic (7), understanding the perceptions and attitudes of the community toward the national response measures for the COVID-19 is critically important for maintaining the success of Vietnam in controlling the epidemic. Thus, this study aimed to assess perceptions and attitudes toward the importance or necessity of national response measures to COVID-19 epidemics among people under the nationwide partial lockdown of Vietnam.

METHODS

Study Setting and Participants

Data from an online cross-sectional survey were obtained within 1 week of the national lockdown in April 2020 due to the COVID-19 epidemic in Vietnam. During this period, all Vietnamese citizens were highly recommended to stay at home to prevent and control the COVID-19 outbreak. The respondents met the following inclusion criteria: (1) Aged 18 years or above; (2) Having ability to access the questionnaire on the web-based survey, and (3) Having ability to read and respond the questionnaire; and (4) Agreeing to take part in the research by approving the online informed consent.

The online survey was developed on the Survey Monkey platform, which had good usability, comprehensive feature sets, and qualified data storage and private information security. Links for the online survey were sent to respondents via email or social media platforms such as Zalo or Facebook. A snowball sampling method was applied in following steps: (1) First, we randomly recruited a core group including 80 staffs and 150 medical students at the Hanoi Medical University with different age and gender; (2) After completing the survey, they were asked to invited other Vietnamese people such as their family members, relatives, or friends in different provinces to participate in the survey. The study protocol was approved by the Institutional Review Board (IRB) of the Institute for Preventive Medicine and Public Health, Hanoi Medical University (Code 75/QD-YHDP&YTCC). A total of 1,382 respondents were enrolled in the study and they were mainly public administration and health workers with relatives.

Measurement

The online questionnaire was developed by the research team to measure sociodemographic characteristics and perceptions about the importance of national response measures to the COVID-19 epidemic in Vietnam. The questionnaire was piloted with 10 staff and medical students at the Hanoi Medical University to ensure the logical order of items, language, and readability of the text in each question. The questionnaire was then revised according to the feedback of the participants and approved by the Institute for Preventive Medicine and Public Health, Hanoi Medical University. Collected information included:

- Socioeconomic status consisted of gender, region, age, family size, marital status, occupation, occupation status, and education level.
- Perceptions and attitudes about the importance of national response measures: Seven questions regarding perceptions about the importance of seven national response measures to COVID-19 epidemics were asked during the nationwide partial lockdown of Vietnam. Participants were asked to answer the questions: "To what extent do you agree or disagree with the importance and necessity of following measures to prevent and control COVID-19 epidemic in Vietnam?" with following seven items: (1) isolate people from abroad and people in contact with those infected with COVID-19; (2) obligatory to wear face masks in public places; (3) blockade of places having new cases; (4) implement social distancing; (5) close unnecessary services; (6) measure body temperature in public places; (7) close educational facilities.

Respondents evaluated the importance or necessity of these national response measures by using a five-level Likert scale (1 = strongly disagree, 2 = disagree, 3 = neutral, 4 = agree, and 5 = strongly agree).

Data Analysis

STATA 15.0 software was used to analyze the data. Since education was a significant predictor for the attitude and perception toward COVID-19 epidemic and measures (30), descriptive statistics were used to examine the differences in the sociodemographic and perceptions among three education levels including "High school and below," "Undergraduate," and "Post-graduate."

In this study, we applied an exploratory factor analysis (EFA) to evaluate the construct validity of the scales. We used the screen test to examine the threshold of eigenvalue, and a value of 1.0 was detected as a threshold for flattening out the curve. We also applied the Orthogonal Varimax rotation and Kaisers' normalization to reallocate seven items into two identified domains. A value of 0.4 was utilized as a cut-off threshold for factor loadings. The internal consistency reliability of each domain was evaluated by computing Cronbach's alpha. The score of each domain was computed by averaging the total score of all items in the domain. Domain's score ranges from 1 to 5. A higher score indicated higher level agreement about the importance/necessity of national response measures.

Given that data of domain scores were censored data, multivariable Tobit regression models were employed to identify factors associated with the perceptions about the importance/necessity of national response measures to COVID-19 epidemics. Independent variables included socioeconomic status (gender, region, age, family size, marital status, occupation, occupation status, and education level), while dependent variables were scores of two new domains, namely "Social distancing and community screening" and "Mandatory quarantine and personal protective equipment." Stepwise forward selection strategies were utilized to produce the reduced models, with a p-value of log-likelihood test of 0.2 as a threshold for including variables into the model. $P < 0.05$ was defined as statistical significance.

Ethical Consideration

The research was ethically approved by the Review Committee at Hanoi Medical University on March 27, 2020. The purpose of research and informed consent was provided online for participants to decide whether to participate. Participation was voluntary, and anonymity was assured. Respondents were able to decline to participate or withdraw from the online survey at any time.

RESULTS

Socioeconomic Characteristics of Respondents

Table 1 shows that among 1,382 participants, 62.0% was female, 47.1% lived in Northern, and 76.7% married. The mean age was 36.4 (SD = 9.7) years old. There were 73.2% of respondents having from 3 to 5 people in the family. The majority of participants were health workers (69.7%), following by white-collar workers (10.4%), and students (6.7%). Most of the respondents had were public employees (64.7%).

Factor Loading of Exploratory Factor Analysis

Table 2 presents the EFA results. The proportion of participants strongly agreeing with the measure "Isolate people from abroad and people in contact with people infected with COVID 19" was the highest (96.9%), following by the measure "Obligatory to wear face masks in public places" (96.8%), and "Blockade of places having new cases" (92.9%). Two domains were reconstructed after the analysis including "Social distancing and community screening" (with 4 items, Cronbach's alpha = 0.74, mean = 4.7, SD = 0.5) and "Mandatory quarantine and personal protective equipment" (with 3 items, Cronbach's alpha = 0.68, mean = 5.0, SD = 0.2).

Perception of National Response Measures to COVID-19 Epidemics Among Respondents

Table 3 depicts that the score of each measure, expect "Close educational facilities" and "Isolate people from abroad and people in contact with people infected with COVID 19," as well as the score of each domain were significantly different among three groups of education level ($p < 0.05$).

TABLE 1 | Socio-economic characteristics of respondents.

	Education level							
	High school and below		Undergraduate		Post-graduate		Total	
	n	%	*n*	%	*n*	%	*n*	%
Total	100	7.2	1,104	79.9	178	12.9	1382	100.0
Gender								
Male	35	35.0	399	36.1	91	51.1	525	38.0
Female	65	65.0	705	63.9	87	48.9	857	62.0
Region								
Northern	62	62.0	479	43.4	110	61.8	651	47.1
Central	31	31.0	434	39.3	37	20.8	502	36.3
South	7	7.0	186	16.8	29	16.3	222	16.1
Foreign people	0	0.0	5	0.5	2	1.1	7	0.5
Age group								
Under 25	65	65.0	48	4.3	0	0.0	113	8.2
25–34	10	10.0	506	45.8	40	22.5	556	40.2
35–44	11	11.0	342	31.0	67	37.6	420	30.4
Above 44	14	14.0	208	18.8	71	39.9	293	21.2
Family size								
1–2 people	24	24.0	170	15.4	20	11.2	214	15.5
3–5 people	68	68.0	807	73.1	137	77.0	1012	73.2
Above 5 people	8	8.0	127	11.5	21	11.8	156	11.3
Marital status								
Single	74	74.0	229	20.7	19	10.7	322	23.3
Married	26	26.0	875	79.3	159	89.3	1060	76.7
Occupation								
Health workers	15	15.0	854	77.4	94	52.8	963	69.7
Professional educators	1	1.0	37	3.4	31	17.4	69	5.0
White collar workers	1	1.0	114	10.3	29	16.3	144	10.4
Students	66	66.0	25	2.3	1	0.6	92	6.7
Others	17	17.0	74	6.7	23	12.9	114	8.2
Type of contract								
Public employment contract*	11	11.0	769	69.7	114	64.0	894	64.7
Permanent employment contract	9	9.0	152	13.8	28	15.7	189	13.7
Fixed-term fulltime contract**	6	6.0	107	9.7	16	9.0	129	9.3
No contract (Farmers/Students/Homemakers/ Unemployed/Retired)	70	70.0	46	4.2	6	3.4	122	8.8
Others	4	4.0	30	2.7	14	7.9	48	3.5
	Mean	***SD***	**Mean**	***SD***	**Mean**	***SD***	**Mean**	***SD***
Number of children	0.7	1.1	1.3	0.9	1.7	0.8	1.3	0.9
Number of children aged above 15	0.3	0.7	0.3	0.7	0.6	0.8	0.4	0.7
Age	28.0	11.9	36.2	9.0	42.1	8.7	36.4	9.7

**Public employment contract: type of contract for people working in public non-business units under working contracts and salaried from salary funds of public non-business units in accordance with law.*

***Fixed-term fulltime contract is a contractual relationship between an employee and an employer that lasts for a specified period. In Vietnam, there are two kinds of fixed-term contracts include the definite term contract of 12–36 months and the seasonal or fixed-term contract of <12 months.*

Associated Factors With the Levels of Perceived Importance of National Response Measures to COVID-19 Epidemics

Table 4 reveals the factors associated with the perceived importance of national response measures to COVID-19 epidemics. People who were female (Coef. = 0.09; 95%CI: 0.04; 0.14), aged 35–44 years old (Coef. = 0.09; 95%CI: 0.03; 0.14) and married (Coef. = 0.07; 95%CI = 0.01; 0.13) had a significantly higher score in "Social distancing and community screening" domain compared with those who were male, aged under 25 years and single, respectively. Meanwhile, living in the Southern region, having a family with more than 5 people, and having post-graduate education were negatively correlated to the levels of perceived importance of this measure group.

In terms of the "Mandatory quarantine and personal protective equipment" measure group, people having post-graduate education level (Coef. = −0.04; 95%CI: −0.07; −0.01), living outside Vietnam (Coef. = −0.22; 95%CI: −0.35; −0.08),

TABLE 2 | Factor loading of exploratory factor analysis.

Items	Strongly agree		Social distancing and community screening	Mandatory quarantine and personal protective equipment
	n	%		
Isolate people from abroad and people in contact with people infected with COVID 19	1,339	96.9		0.85
Obligatory to wear face masks in public places	1,338	96.8		0.81
Blockade of places having new cases	1,284	92.9		0.69
Implement social distancing	1,068	77.3	0.80	
Close unnecessary services	1,063	76.9	0.80	
Measure body temperature in public places	1,015	73.4	0.57	
Close educational facilities	940	68.0	0.75	
Cronbach's alpha			0.74	0.68
Mean (1–5)			4.7	5.0
SD			0.5	0.2

TABLE 3 | Perception of national response measures to COVID-19 epidemics among respondents.

	Education level								*p*-value
	High school and below		Undergraduate		Post-graduate		Total		
	Mean	*SD*	Mean	*SD*	Mean	SD	Mean	*SD*	
Social distancing and community screening	4.7	0.4	4.7	0.4	4.5	0.6	4.7	0.5	<0.01
Close educational facilities	4.6	0.5	4.6	0.7	4.6	0.7	4.6	0.7	0.60
Measure body temperature in public places	4.7	0.5	4.7	0.6	4.4	0.8	4.7	0.6	<0.01
Implement social distancing	4.7	0.6	4.7	0.6	4.6	0.7	4.7	0.6	0.02
Close unnecessary services	4.6	0.6	4.8	0.5	4.6	0.7	4.7	0.6	<0.01
Mandatory quarantine and personal protective equipment	4.9	0.2	5.0	0.2	4.9	0.2	5.0	0.2	<0.01
Obligatory to wear face masks in public place	5.0	0.2	5.0	0.2	4.9	0.3	5.0	0.2	0.01
Isolate people from abroad and people in contact with people infected with COVID 19	4.9	0.3	5.0	0.2	5.0	0.2	5.0	0.2	0.49
Blockade of places having new cases	4.9	0.3	4.9	0.3	4.8	0.4	4.9	0.3	<0.01

working as white-collar workers (Coef. = −0.04; 95%CI: −0.08; −0.01), and having full-time employment contracts (Coef. = −0.07; 95%CI: −0.10; −0.03) were inversely associated with the levels of perceived importance of the measures.

DISCUSSION

This study was performed during the national lockdown in Vietnam, which might be helpful to reflect the perceptions and attitudes of the general population toward national response measures to address the COVID-19 epidemic. Findings from this study showed a high level of agreement among the general population toward the importance and necessity of national response measures to combat the COVID-19 epidemic. Moreover, the result indicated regional variations in the perceived importance, as well as the drivers of these perceptions, such as gender, educational level, marital status, family size, occupation, and participants' employment status. The finding from our study can inform governments in implementing appropriate measures in the coming epidemics.

As being aware of challenges ahead regarding limited resources and healthcare capacities (31), the Government of

TABLE 4 | Associated factors with the levels of perceived importance of national response measures to COVID-19 epidemics.

Characteristics	Social distancing and community screening		Mandatory quarantine and personal protective equipment	
	Coef.	95% CI	Coef.	95% CI
Region (vs. Northern)				
Southern	−0.13***	−0.19; −0.06		
Foreign			−0.22***	−0.35; −0.08
Gender (vs. Male)				
Female	0.09***	0.04; 0.14	0.02*	−0.00; 0.04
Age group (vs. Under 25)				
35–44	0.09***	0.03; 0.14		
Number of children			−0.02**	−0.03; −0.00
Marital status (vs. Single)				
Married	0.07**	0.01; 0.13	0.03	−0.01; 0.06
Family size (vs. 1–2 people)				
Above 5 people	−0.10***	−0.18; −0.03		
Education level (vs. High school and below)				
Post-graduate	−0.18***	−0.25; −0.10	−0.04***	−0.07; −0.01
Occupation (vs. Health workers)				
White-collar workers			−0.04***	−0.08; −0.01
Others	0.07	−0.02; 0.15		
Occupation status (vs. Public employment contract)				
Fixed-term fulltime contract			−0.07***	−0.10; −0.03
No contract			−0.03	−0.07; 0.01

$^{***}p < 0.01$, $^{**}p < 0.05$, and $^{*}p < 0.1$.

Vietnam had implemented various mandatory measures in the early phase of the epidemic to "flattening the curve" (32). It is necessary for the government to have time for preparing a possible upsurge in the number of COVID-19 cases and forecasting the pandemic peak in the next stages (13, 33, 34). Findings from our study indicated a significantly high agreement about the importance of response measures that the Government performed during the epidemic. This phenomenon can be explained that along with the role of the Government's leadership, the transparency in epidemic information and the great involvement of mass media were critically important in developing the beliefs of the community in the Government's actions, and the importance of changing behaviors such as wearing masks, good hygiene, social distancing, or compulsory quarantine (32, 35, 36). Our study implied a high acceptance and feasibility of these measures if they had to be performed in the future.

In this study, we found regional variations in the perceptions toward the importance of national measures. Specifically, living in the Southern region was negatively correlated with the perceived importance of the social distancing measure group. Differences in financial management and daily habits between the South residents and other parts in Vietnam could help to explain this difference. People in Southern provinces are less likely to have available savings for risk prevention, as compared to the Northern residents (37). Social distancing or national lockdown may lead to fear of job losses, salary cuts, and unguaranteed living expenses for the family, which might be more burdensome among Southern people than those in other regions. Therefore, further national preventive measures implementation should consider the cultural background of each set to improve its feasibility and acceptability among general populations in this setting.

A recent study found that there was no difference in adherence to precautionary measures between white and blue-collar workers (4). Our findings showed that those who were white-collar workers had a lower score in the "Mandatory quarantine and personal protective equipment" compared to the health workers. Indeed, they could be classified in a lower risk of COVID-19 than health professionals, and they were allowed to work at home during the epidemic (4). Therefore, we assumed that using personal protective equipment such as facemask seems to be undervalued in this group due to their subjective sensation of safety when working from home. This reason can be applied to respondents with post-graduate education who had lower scores in both measure groups compared to those having only high school education or lower. Moreover, it means that merely educated people with higher social status underestimated mitigation strategies that touch more others than themselves. In western countries, adhering COVID 19 preventive measures was faced with skepticism by the public, even creating panic in a particular situation such as some authorities has discouraged using masks and personal protective equipment (PPE) with the reasons that its no effective protection against COVID 19

(13) and psychological barriers including using the mask and PPE as contradictory to individualism (38). Regarding cultural underpinnings aspects, using masks as well as PPE was partially restricted by the recommendation of no mask use under the context of rising political demonstration and terrorist attacks. However, this has not mentioned in literature. The former group was more likely to have stable jobs and incomes; thus, they might not be affected by the national measures. Meanwhile, people who had fixed-term employment contracts had lower levels of agreement about the importance of these measures compared to other groups. In particular, the fixed-term fulltime contract is a contractual relationship between an employee and an employer that lasts for a specified period. In Vietnam, there are two kinds of fixed-term contracts include the definite term contract of 12–36 months and the seasonal or fixed-term contract of <12 months. It may be explained that in Vietnam, people under this type of contract are at higher risk of suffering from absorbing layoffs or salary cuts without alternative income sources, or in other words, they might face substantial financial burden when they or their living areas were under quarantine. Simultaneously, those with public employment contracts could be guaranteed with full salary and monthly living expenses when occurring natural disasters or epidemics according to the Vietnamese regulations (39). Similar groups are at risk from job loss in other countries (40), which possibly reduces their positive perceptions toward the national response measures. Similarly, participants with large family size also had lower levels of agreements about the importance of "Social distancing and community screening." These measures might cause a greater economic crisis if they lost their jobs (40).

The findings of this study indicate several implications that can be helpful in further COVID-19 and other disease epidemics in Vietnam. First, strategies to maintain and improve the perceptions of the general population toward COVID-19 and national response measures should be performed regularly to ensure that people can have sufficient preparations if the epidemic returns. Second, further preventive strategies should be contextualized to different settings to optimize their effectiveness and acceptance. Third, more studies about how people cope with the difficulties during the epidemic should be implemented in order to help to timely provide appropriate supportive interventions.

Through its rapid assessment, this study provides timely and valuable information on the perceptions and attitudes of Vietnamese people in the unique lock-down situation. However, findings of the study should be viewed in light of its limitations. First, this study used the cross-sectional design, which might hinder our ability to draw causal conclusions between people's perceptions and associated factors. Second, the snowball sampling technique used in this study possibly led to selection bias given that most of our participants were health professionals. This might limit our generalizability to the entire Vietnamese people. However, since these individuals have a central role in orienting the preventive behaviors of people in the community (41), their positive perceptions toward the national response measures is an important assurance for the success of these measures in the future. Third, our survey were administrated via online platform. Nonetheless, in the limited resource settings such as Vietnam, implementing online survey is an optimal manner to reach a large sample size quickly in various settings. Moreover, in order to increase the reliability and validity of the data, we carefully piloted the survey and presented the questionnaire in the survey platform with the most convenient way for participants to answer the questions. Fourth, given the urgent nature of the study and the challenge of participants recruitment during lockdown time, we were not able to collect a larger and more diverse sample. Thus, future studies are encouraged to consider investing more time and effort to enroll more participants with more diverse background. Further studies may also benefit from assessing the cultural aspects related to the Vietnamese's perceptions and attitudes toward COVID 19 and national response measures, in particular religious beliefs, which might be one of the factors contributing to acceptance trends of COVID-19 prevention measures in certain population groups of a multi-religious country such as Vietnam.

In conclusion, this study determined some negative perceptions and attitudes toward the national response measure to combat COVID-19 epidemic in Vietnam, including citizens who live in the Southern region, white-collar workers, post-graduate education people, and laborers with fixed-term employment contracts. Contextualized strategies to maintain and improve these perceptions should be warranted to ensure the success of the preventive measures in the future.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by the study was reviewed and approved by the Review Committee of Hanoi Medical University dated 28 March 2020. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

TTPN, LN, HL, GV, MH, DN, XL, BT, TTN, QP, NT, QN, CL, RH, and CH: conceptualization and writing—review and editing. DN, TTN, QP, NT, and QN: data curation. TTPN, LN, and XL: data analysis. TTPN, LN, HL, GV, BT, and RH: methodology. HL, XL, BT, CL, RH, and CH: supervision. TTPN, LN, HL, GV, and MH: writing—original draft. GV, MH, and TTN: project administration. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Chan JF-W, Yuan S, Kok K-H, To KK-W, Chu H, Yang J, et al. A familial cluster of pneumonia associated with the 2019 novel coronavirus indicating person-to-person transmission: a study of a family cluster. *Lancet*. (2020) 395:514–23. doi: 10.1016/S0140-6736(20)30154-9
2. World Health Organization. *Coronavirus Disease (COVID-19) Outbreak Situation*. (2020) Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019 (accessed April 30, 2020).
3. World Health Organization. *Coronavirus (COVID-19)*. Geneva: World Health Organization (2020). Available online at: https://covid19.who.int/ (accessed June 9, 2020).
4. Tan W, Hao F, McIntyre RS, Jiang L, Jiang X, Zhang L, et al. Is returning to work during the COVID-19 pandemic stressful? A study on immediate mental health status and psychoneuroimmunity prevention measures of Chinese workforce. *Brain Behav Immun*. (2020) 87:84–92. doi: 10.1016/j.bbi.2020.04.055
5. Prevention USoCfDCa. *How 2019-nCoV Spreads: United States of Centers for Disease Control and Prevention*. (2020) Available online at: https://web.archive.org/web/20200128152653/https://www.cdc.gov/coronavirus/2019-ncov/about/transmission.html (accessed January 27, 2020).
6. Organization WH. *Q&A on coronaviruses (COVID-19): World Health Organization*. (2020) Available online at: https://web.archive.org/web/20200120174649/https://www.who.int/news-room/q-a-detail/q-a-coronaviruses (accesssed January 9, 2020).
7. Kandel N, Chungong S, Omaar A, Xing J. Health security capacities in the context of COVID-19 outbreak: an analysis of international health regulations annual report data from 182 countries. *Lancet*. (2020) 395:1047–53. doi: 10.1016/S0140-6736(20)30553-5
8. Ferguson N, Laydon D, Nedjati Gilani G, Imai N, Ainslie K, Baguelin M, et al. *Report 9: Impact of Non-Pharmaceutical Interventions (NPIs) to Reduce COVID19 Mortality and Healthcare Demand*. London: Faculty of Medicine, School of Public Health, Imperial College London (2020).
9. Person B, Sy F, Holton K, Govert B, Liang A. National center for inectious diseases SCOT. Fear and stigma: the epidemic within the SARS outbreak. *Emerg Infect Dis*. (2004) 10:358–63. doi: 10.3201/eid1002.030750
10. Tao N. An analysis on reasons of SARS-induced psychological panic among students. *J Anhui Inst Educ*. (2003) 21:78–9.
11. Floyd DL, Prentice-Dunn S, Rogers RW. A meta-analysis of research on protection motivation theory. *J Appl Soc Psychol*. (2000) 30:407–29. doi: 10.1111/j.1559-1816.2000.tb02323.x
12. Rogers RW. A protection motivation theory of fear appeals and attitude change1. *J Psychol*. (1975) 91:93–114. doi: 10.1080/00223980.1975.9915803
13. Feng S, Shen C, Xia N, Song W, Fan M, Cowling BJ. Rational use of face masks in the COVID-19 pandemic. *Lancet Respir Med*. (2020) 8:434–6. doi: 10.1016/S2213-2600(20)30134-X
14. Bish A, Michie S. Demographic and attitudinal determinants of protective behaviours during a pandemic: a review. *Br J Health Psychol*. (2010) 15:797–824. doi: 10.1348/135910710X485826
15. Leppin A, Aro AR. Risk perceptions related to SARS and avian influenza: theoretical foundations of current empirical research. *Int J Behav Med*. (2009) 16:7–29. doi: 10.1007/s12529-008-9002-8
16. Poletti P, Ajelli M, Merler S. The effect of risk perception on the 2009 H1N1 pandemic influenza dynamics. *PLoS ONE*. (2011) 6:e0016460. doi: 10.1371/journal.pone.0016460
17. Rubin GJ, Amlôt R, Page L, Wessely S. Public perceptions, anxiety, and behaviour change in relation to the swine flu outbreak: cross sectional telephone survey. *Bmj*. (2009) 339:b2651. doi: 10.1136/bmj.b2651
18. van der Weerd W, Timmermans DR, Beaujean DJ, Oudhoff J, van Steenbergen JE. Monitoring the level of government trust, risk perception and intention of the general public to adopt protective measures during the influenza A (H1N1) pandemic in the Netherlands. *BMC Public Health*. (2011) 11:575. doi: 10.1186/1471-2458-11-575
19. Brewer NT, Chapman GB, Gibbons FX, Gerrard M, McCaul KD, Weinstein ND. Meta-analysis of the relationship between risk perception and health behavior: the example of vaccination. *Health Psychol*. (2007) 26:136. doi: 10.1037/0278-6133.26.2.136
20. Agency CI. *The World Factbook—Vietnam: Central Intelligence Agency*. (2020) Available online at: https://www.cia.gov/library/publications/the-world-factbook/geos/vm.html (accessed April 30, 2020).
21. Agency VN. *Vietnam Declares Novel Coronavirus Epidemic: Vietnam News Agency*. (2020) Available online at: https://en.vietnamplus.vn/vietnam-declares-novel-coronavirus-epidemic/168021.vnp (accessed February 1, 2020).
22. online Tt. *"Stop all flights between Vietnam and China": Tuoi tre Online*. (2020) Available online at: https://tuoitre.vn/dung-toan-bo-chuyen-bay-giua-viet-nam-va-trung-quoc-tu-chieu-nay-20200201155919672.htm (accessed February 1, 2020).
23. Dung MT. *Official Dispatch No 716/VPCP-KGVX dated 02/02/2020 of Vietnam Government Office on Steering Allows Closure of Schools, Universities*. (2020).
24. Phuc NX. *Directive No 06/CT-TTg Dated 31/01/2020 of the Vietnam Prime Minister on Strengthening Measures to Prevent the Complex Developments of COVID-19*. (2020).
25. Phuc NX. *Notification No 102/TB-VPCP Dated 17/03/2020 on the Conclusion of the Vietnam Prime Minister Government on COVID-19 Prevention*. (2020).
26. VNExpress. *Implementing Health Declaration for all Residents in Vietnam:* VNExpress (2020) Available online at: https://vnexpress.net/viet-nam-thuc-hien-khai-bao-suc-khoe-toan-dan-4066152.html (accessed March 8, 2020).
27. Phuc NX. *Directive No 16/CT-TTg of Vietnam Prime Minister on Implementation of Urgent Measures to Prevent and Control COVID 19*. (2020).
28. Phuc NX. *Directive No 16/CT-TTg of Vietnam Prime Minister on the Implementation of Urgent Measures to Prevent and Control the COVID-19 Epidemic*. (2020).
29. Vietnam MoHo. *Updated Information Web Page on Disease COVID−19: Ministry of Health of Vietnam*. (2020). Available online at: https://ncov.moh.gov.vn/ (accessed June 2, 2020).
30. Zhong BL, Luo W, Li HM, Zhang QQ, Liu XG, Li WT, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *Int J Biol Sci*. (2020) 16:1745–52. doi: 10.7150/ijbs.45221
31. Ha BTT, Ngoc Quang L, Mirzoev T, Tai NT, Thai PQ, Dinh PC. Combating the COVID-19 epidemic: experiences from Vietnam. *Int J Environ Res Public Health*. (2020) 17:3125. doi: 10.3390/ijerph17093125
32. Le TA, Ha GH, Le MQT, Tran LMH, Pham DTT, Tran NHT, et al. Treatment adherence amongst drug users attending public and private methadone maintenance clinics in a northern province of Vietnam. *Subst Abuse Treat Prev Policy*. (2020) 15:31. doi: 10.1186/s13011-020-00271-9
33. Lancet T. India under COVID-19 lockdown. *Lancet*. (2020) 395:1315. doi: 10.1016/S0140-6736(20)30938-7
34. Salathé M, Althaus CL, Neher R, Stringhini S, Hodcroft E, Fellay J, et al. COVID-19 epidemic in Switzerland: on the importance of testing, contact tracing and isolation. *Swiss Med Weekly*. (2020) 150:w20225. doi: 10.4414/smw.2020.20225
35. Huynh TLD. The COVID-19 containment in Vietnam: what are we doing? *J Glob Health*. (2020) 10:010338. doi: 10.7189/jogh.10.010338
36. Tran BX, Hoang MT, Pham HQ, Hoang CL, Le HT, Latkin CA, et al. The operational readiness capacities of the grassroots health system in responses to epidemics: Implications for COVID-19 control in Vietnam. *J Glob Health*. (2020) 10:011006. doi: 10.7189/jogh.10.011006
37. Dung NT, Anh CTL. The difference in geographical culture and borrowing consumer behavior of people in Hanoi and ho chi minh city. *VNU J Sci*. (2019) 35:4276. doi: 10.25073/2588-1108/vnueab.4276
38. World Health Organization. Ten things you need to know about pandemic influenza (update of 14 October 2005). *Wkly Epidemiol Rec*. (2005) 80:428–31.
39. Trong NP. *The Law No. 58/2010/QH12 of on Regulations on Officials in Vietnam*. (2020).
40. (ILO) ILO. ILO: *As Job Losses Escalate, Nearly Half of Global Workforce at Risk of Losing Livelihoods*. International Labour Organization (ILO) (2020). Available online at: https://www.ilo.org/global/about-the-ilo/newsroom/news/WCMS_743036/lang--en/index.htm (accessed April 29, 2020).

41. Xuan Tran B, Thi Nguyen H, Quang Pham H, Thi Le H, Thu Vu G, Latkin CA, et al. Capacity of local authority and community on epidemic response in Vietnam: implication for COVID-19 preparedness. *Saf Sci.* (2020) 130:104867. doi: 10.1016/j.ssci.2020.104867

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Systems Thinking About SARS-CoV-2

*Rainer Johannes Klement**

Department of Radiation Oncology, Leopoldina Hospital, Schweinfurt, Germany

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INTRODUCTION: SYSTEMISM AND SYSTEMS THINKING

> "[T]he good physician is a systemist: she prefers syndromes to isolated symptoms, places the body in its environment, and takes into account all the relevant levels of organization of matter, from the physical to the social." (1, pp.45-46).

This quote from Mario Bunge, the Argentinian physicist and philosopher who authored more than 500 papers and 50 books and died at age 100 this year, will be taken as the starting point for a critical appraisal of the role that systems thinking has played or not in the management of the SARS-CoV-2 epidemic.

The terms "systemist" in Bunge's quote and "systems thinking" are closely connected; the former relates to ontology, the latter to a corresponding epistemology. According to Bunge, a systemist is someone who is committed to the worldview of systemism which immune system, can be summarized in the formula "Every existent is either a system or part of a system" [(1), p.47]. A consequence of systemism is that the generation of knowledge about the world requires the usage of certain analytic skills in order to identify and understand systems, predict their behavior and modify them in order to produce desired effects (experimentation). This epistemological approach will be defined as systems thinking (2). Accordingly, a good physician should be a systems thinker, someone who tries to identify and take into account the various systems and their components that make up and interact with a given patient. The skills required for systems thinking consist of recognizing interconnections between parts of a system (the base level of systems thinking), identifying and understanding cause-effect feedback loops, understanding system structure, dynamic behavior and systems at different scales ("systems of systems"), and lessening a system's complexity through various methods such as reduction or abstraction (2). These analytic skills are not only important when dealing with an individual patient, but especially when the aim is to improve population health through cross-disciplinary research, i.e., multi-, inter-, and transdisciplinarity (3, 4). Thereby, according to the definition of Rosenfield (3), multidisciplinarity means that researchers from several subdisciplines independently tackle a research problem in parallel or sequentially, i.e., without really working together, to contribute to an overall picture or solution. Interdisciplinarity also involves researchers working within their specific subdisciplines, but now jointly together. Finally, transdisciplinarity transcends disciplinary borders by working in a shared conceptual framework. Transdisciplinarity requires cross-disciplinary understanding between members of the research team and is necessary to obtain knowledge about emergent phenomena within systems [(4), p.86]. Such emergent phenomena cannot be explained by referring to lower levels of a system, i.e., via reduction. Transdisciplinary research and knowledge is therefore especially relevant for public health problems which involve emergent phenomena (5).

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Julie Abimanyi-Ochom,
Deakin University, Australia

***Correspondence:**
Rainer Johannes Klement
rainer_klement@gmx.de
orcid.org/0000-0003-1401-4270

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IMPLICATIONS OF SYSTEMS THINKING DURING THE SARS-COV-2 OUTBREAK

Unfortunately, we live in an age in which fewer and fewer scholars have serious competence beyond their own increasingly narrow field of research (6). This is particularly reflected within the medical sciences, in which material reductionism, the view that every level of phenomena can be explained by causal effects of material particles at a lower level, is the default ontology (7, 8), apparently superseding cross-disciplinary, and in particular transdisciplinary research. While material reductionism has led to great advances in the natural sciences dealing with the non-living world, it faces serious problems when applied to sciences dealing with living, multicellular organisms and their societies both of which can be conceptualized as open systems with emergent properties (9, 10). Thus, physicians and public health authorities should resist reductionist thinking and instead try to identify and study system structures and causal loops of the problem at hand, integrating all relevant disciplines within an inter- and transdisciplinary approach.

Sahin et al. (11) recently developed a preliminary causal loop diagram (CLD) depicting many of the causal feedback loops within the environmental-health-socio-economic system of the SARS-CoV-2 problem. While their CLD is a valuable starting point for informing policy interventions against the SARS-CoV-2 and future outbreaks of other infectious pathogens, it has neglected the system of the individual person that the various medical disciplines are concerned with. I have therefore created a modified CLD based on the work of Sahin et al. (11) which includes the system of an individual and other components that I found to be under-represented in discussions about the SARS-CoV-2 crisis (**Figure 1**). These are briefly described in the following.

A Functioning Immune System

A functioning immune system on the level of the individual is a major determinant of the susceptibility to infection as well as the severity of symptoms. The fact that ∼40–45% of SARS-CoV-2 infections remain asymptomatic (12) indicates that innate and adaptive immunity have the power to effectively handle this virus. For example, triggering of innate immune adaptions through influenza vaccination has been proposed as a protective measure against COVID-19 severity (13), which indeed received some confirmation in (not yet peer-reviewed) observational studies (14, 15). It has also been proposed that the adaptive immune system may account for a significant protection in certain individuals through cross-reactivity between B- and T-cell epitopes of SARS-CoV-2 and other human coronaviruses (16). Indeed, cross-reactive T-cell responses against SARS-CoV-2 associated with "common cold" coronaviruses have been detected in about 30–80% of unexposed individuals (17–20). Unfortunately, the computer models that had been used to justify the lockdown interventions in many Western countries had not taken these immune responses offering partial protection of a significant percentage of the population into account (21, 22)[1]–an example of "looking at only one or a few dimensions of the problem at hand" (reductionism) and "lack of expertise in crucial disciplines" (inter- and transdisciplinarity) that Ioannidis et al. identified as factors contributing to these models wrongly predicting COVID-19 fatalities by orders of magnitude (24).

Furthermore, the public is rarely informed that an optimally functioning immune system requires the presence or absence of certain factors. Some of these factors are studied within the transdisciplinary field of *nutritional immunology*. Healthy nutrition, i.e., an optimal macro-, micro- and trace nutrient composition, positively supports innate and adaptive immunity (path A in **Figure 1**). While the interactions between nutrition and the immune system are complex and pose a multidimensional problem (25), it is well-established that an adequate intake of protein and certain vitamins and trace elements is needed for an optimally functioning immune system and the containment of respiratory virus-induced inflammation (26, 27). For example, SARS-CoV-2, influenza and other respiratory viruses activate the cytoplasmic nucleotide-binding domain (NOD)-like receptor protein 3 (NLRP3) inflammasome in immune cells (typically monocytes and macrophages), which produces and activates interleukin (IL)-1β and further downstream cytokines, causing flu-like symptoms and tissue damage (28). Several nutrients and secondary plant substances have been shown to reduce NLRP3 inflammasome activation (29), among them vitamin C (ascorbic acid), which may be especially active against coronaviruses (30), or the ketone body β-hydroxybutyrate (31). Evidence for protective effects against COVID-19 has emerged for some of these nutrients, in particular zinc, selenium, N-acetyl-cystein and vitamin C, although it is limited to non-randomized studies (27, 32). The strongest evidence to date is available for vitamin D whose main natural supply is not through diet, but solar UV-B radiation on the skin (path B in **Figure 1**). Higher vitamin D levels have been linked to lower COVID-19 incidence, death rates and hospitalizations in epidemiological studies (33–35). First clinical data suggested that higher vitamin D levels are associated with less severe courses of COVID-19 (36, 37). A recent randomized controlled trial has shown a highly significant benefit of high vitamin D supplementation in COVID-19 patients: out of 50 patients receiving 25-hydroxyvitamin D in addition to standard treatment[2] only one required intensive care unit admission compared to 13 out of 26 patients having not received vitamin D ($p < 0.001$) (38). Given the cost-effectiveness and safety of vitamin D and other immune-supporting nutrient supplements, some authors have rightfully argued that public health officials should encourage their

[1]I have thoroughly analyzed this and other problems in the modeling study of Flaxman et al. (22) in a German online article (23); for example, their model assumes that every infection causes a secondary infection until 100% of the population had been infected which is at odds with the observations of pre-existing immunity.

[2]The dose was 0.532 mg (21280 I.U.) on day 1, followed by 0.266 mg (10640 I.U.) on days 3 and 7 and 0.266 mg weekly thereafter (38).

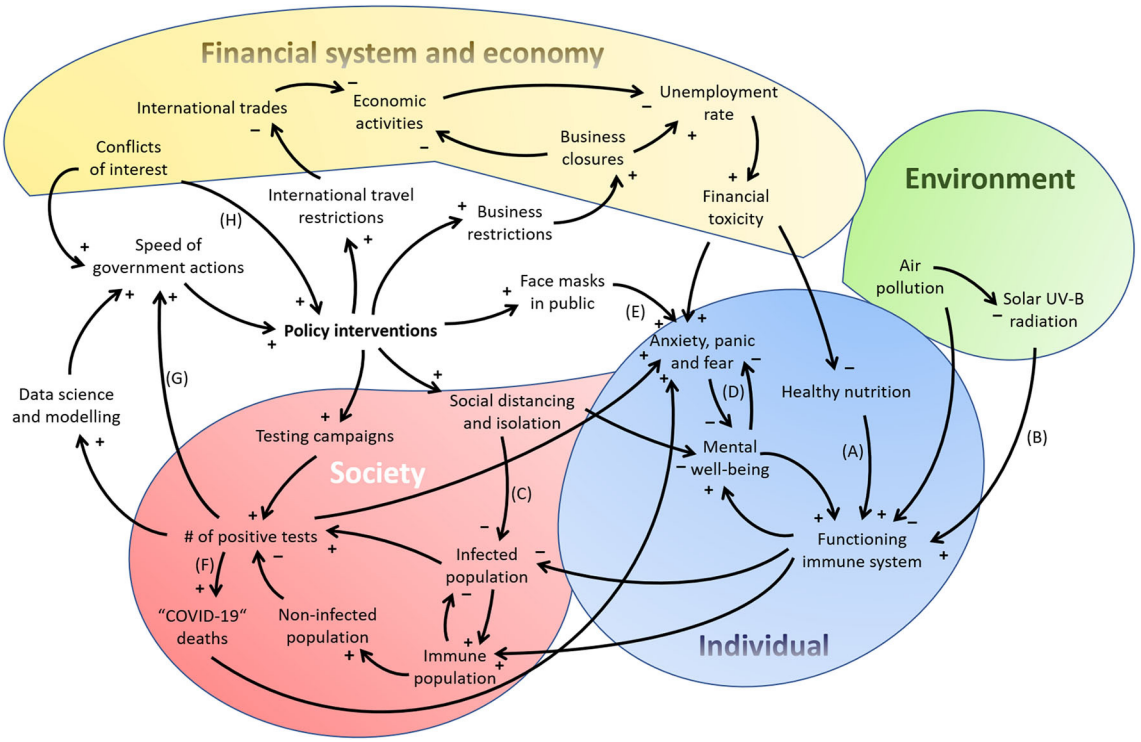

FIGURE 1 | A preliminary causal loop diagram displaying the complexity of the SARS-CoV-2 crisis' environmental-individual-socio-economic-political system. Based on Figure 1 of Sahin et al. (11), but extended in some components and simplified in others not relevant for my main arguments here.

adequate intake through a healthy diet and supplementation (26, 27).

Other important insights into immune system regulation come from the field of *psychoneuroimmunology*. This field investigates how psychological stress disrupts hormone and immune regulation; stress in mice, e.g., increases IL-1β through NLRP3 activation in the hippocampus (39). Mario Bunge goes even further by claiming that stress crosses not only three, but five disciplinary boundaries. He includes in this consideration "all levels of organization," up to the social, making stress a "psycho-neuro-endocrino-immuno-social disease" [(1), p.68]. Social distancing and isolation, while possibly decreasing the transmission of infectious pathogens (path C in **Figure 1**), also decreases mental well-being by increasing psychological stress, anxiety and fear (40–42) (loop D in **Figure 1**). Enforced prolonged wearing of face masks is also problematic, as demonstrated by Daniela Prousa who revealed that ∼60% of the German population experienced severe psychosocial problems already 5–7 weeks after installment of a public mask wearing decree (43) (path E in **Figure 1**).

SARS-CoV-2 Tests and Statistical Illiteracy

Testing for SARS-CoV-2 using polymerase chain reaction (PCR) or serum antibody tests is required to accurately map the spread of the disease within and across nations, although politics have failed to use such data in international cooperation (44). Furthermore, efforts to obtain reliable estimates for test sensitivity, specificity and the so-called base rate (or disease prevalence) have been sparse, although these quantities are essential for the logical inferences that can be made from a positive test result (45).

Some studies reported problems with both sensitivity and specificity of commercially available SARS-CoV-2 PCR tests (46, 47). Instead of acknowledging these limitations, positively tested individuals are still routinely nominated as infected individuals in the media, which is *de facto* wrong. Furthermore, many newspapers still simply report the daily or cumulative amount of positive PCR tests, without standardizing to the total number of tests performed and/or population number. This could lead to the impression that the prevalence of SARS-CoV-2 infection rises even if it declines or stays constant. For example, in Germany the number of weekly SARS-CoV-2 PCR tests has been increased to over one million until the end of August 2020, so that the absolute number of positive tests increased along with the number of performed tests, while the percentage of positive tests had remained $<1.5\%$ since mid-May and $\leq 1.0\%$ since end of June (48). Still, German chancellor Angela Merkel proclaimed in a press conference on August 28th that "the infection numbers have clearly risen during the past weeks" (49). Furthermore, in their discussion of the test statistics, even the Robert-Koch-Institute did not mention that the base rate

needs to be accounted for when interpreting a positive test result (48), thereby committing what is called the base rate fallacy (50).

The "collective statistical illiteracy" of health care professionals, journalists and politicians (51, 52) is nothing more than a lack of transdisciplinary knowledge in mathematics and statistics. It is contributing to incorrect information about the spread of the SARS-CoV-2 with the effect of increasing both the public fear and impulsive actions from governments (paths F and G in **Figure 1**).

Learning From Past Epidemics

Given the leading role of the World Health Organization (WHO) in estimating the severity of infectious disease outbreaks, we should consider how the WHO has influenced policy decisions in the past. Doing so, it appears that the WHO has overestimated the severity of several recent "pandemics": SARS in 2002/2003, avian flu in 2005/2006 and Swine flu in 2009. This was likely due to the WHO basing its recommendations on a reductionist assessment made by molecular virologists (53), a mistake that I think is repeated in the current SARS-CoV-2 epidemic.

In addition, financial ties with the pharmaceutical industry of scientific advisors to WHO and international and national public health institutions have likely influenced public health policies during past virus outbreaks, e.g., driving a massive vaccination campaign during the swine flu pandemic that earned the pharmaceutical industry 18 billion Euro (53). Today, the WHO is financed to a large degree by the private Bill and Melinda Gates foundation from which it received more than 228 million US$ in 2018 (54). The Bill and Melinda Gates foundation also funds several institutes that have large influence on decision-makers during the COVID-19 epidemic[3], as well as the GAVI vaccine alliance which in turn funds the WHO (55, 56). Learning from past epidemics means that critical journalists and scientists must watch carefully if financial conflicts of interest might again influence policy decisions during the SARS-CoV-2 crisis (path H in **Figure 1**), in particular if these decisions cannot be justified by inter- and transdisciplinary science.

DISCUSSION

The complexity of the SARS-CoV-2 crisis, and most of the cross-disciplinary considerations associated with it, should have profound consequences for public health measures and personal behavior (57). If the system of an individual is considered, it must be asked why policies have not been directed more toward a positive message of self-responsibility in the sense that people can actively strengthen their immune system. Instead, the daily media messages about the latest rise in infection numbers (which as stated above are only positively tested persons) as well as the installment of drastic measures all over the World fuel the narrative of us all being potential victims of a killer virus that can only be held back through physical barriers, extreme hygiene and ultimately vaccination (58)—a reductionist approach purely focused on the virus without considering the context of the human host, its immune system, microbiome and economic, social and natural environment. This raises many severe problems. For example, in poorer countries inadequate nutrition, financial toxicity and extreme stress induced by governmental lockdown measures without adequate relief strategies can lead to many deaths that remain invisible compared to those presented on COVID-19 dashboards; they can be attributed to a reductionist epidemiological and/or virological view of the problem (59). Along these lines, reductionist thinking raises many ethical issues, namely if avoiding risk of infection at any cost should outweigh other human values such as mental health, social contacts, dying in presence of the family, and basic human rights such as adequate nutrition and freedom of peaceful assembly. Here, more interdisciplinary discussions among health care professionals and scholars of the arts and humanities appear necessary.

As a final example, if systems thinking is employed it should be clear that the high death rates in Northern Italy in Spring 2020 could not simply be extrapolated to other countries given the characteristics of the population [very old, many smokers, high mesothelioma rates (60)], the environment (one of the most crowded and heaviest air-polluted regions in Italy) and the healthcare system ["decades of financial cuts, privatization, and deprivation of human and technical resources" (61)]. Although Italy has often been used for sustaining the mainstream "deadly virus" narrative for the public, such details about the healthcare system and population characteristics are specialist facts that make life more complicated, but need to be considered in order to avoid unnecessary public fear (58).

In summary, it is my argument that journalism, politics, and medicine involved within the SARS-CoV-2 crisis have maintained a rather simple narrative and reductionist thinking thus far. In my opinion we need more journalists interested in accurately informing the public about the complex facts associated with SARS-CoV-2; we further need more politicians willing to be advised from a much broader spectrum of industry- and financially independent scholars than just a few selected virologists and epidemiologists with putative financial or other conflicts of interest. Finally, we need more inter- and transdisciplinary science (62), in particular as retrospective analyses indicate that some drastic policy decisions had no clear benefit (63, 64), and may even have caused more harm than good (43, 59, 65). My hope is that the critical systems perspective on the COVID-19 crisis presented here may be considered for the improvement of both public health and individual well-being.

AUTHOR CONTRIBUTIONS

RJK conducted the research and wrote and approved the manuscript.

[3]These include the Johns Hopkins University which maintains the global SARS-CoV-2 statistics, the German Robert Koch-Institute and the Charité Hospital in Berlin which employs Prof. Drosten, one of the leading government advisors during the crisis (55).

REFERENCES

1. Bunge M. Medical philosophy: conceptual issues. In: *Medicine*. 1st ed. Singapore: World Scientific Publishing Co Pte Ltd (2013). doi: 10.1142/8825
2. Arnold RD, Wade JP. A definition of systems thinking: a systems approach. *Procedia Comput Sci.* (2015) 44:669–78. doi: 10.1016/j.procs.2015.03.050
3. Rosenfield PL. The potential of transdisciplinary research for sustaining and extending lnkages between the health and social sciences. *Soc Sci Med.* (1992) 35:1343–57. doi: 10.1016/0277-9536(92)90038-R
4. Bhaskar R. *Enlightened Common Sense: The Philosophy of Critical Realism*. 1st ed. Hartwig M. editor. New York, NY: Routledge (2016). doi: 10.4324/9781315542942
5. Leischow SJ, Best A, Trochim WM, Clark PI, Gallagher RS, Marcus SE, et al. Systems thinking to improve the public's health. *Am J Prev Med.* (2008) 35:196–203. doi: 10.1016/j.amepre.2008.05.014
6. Matthews MR. Mario Bunge, systematic philosophy and science education: an introduction. *Sci Educ.* (2012) 21:1393–1403. doi: 10.1007/s11191-012-9530-0
7. Thompson RP, Upshur REG. Materialism and reductionism in science and medicine. In: *Philosophy of Medicine: An Introduction* New York, NY: Routledge. (1995). pp. 43–49. doi: 10.4324/9781315159843-5
8. Walach H. Inner experience – direct access to reality: a complementarist ontology and dual aspect monism support a broader epistemology. *Front Psychol.* (2020) 11:640. doi: 10.3389/fpsyg.2020.00640
9. von Bertalanffy L. An outline of general system theory. *Br J Philos Sci.* (1950) 1:134–165. doi: 10.1093/bjps/I.2.134
10. Klement RJ, Bandyopadhyay PS. Emergence and evidence: a close look at Bunge's philosophy of medicine. *Philosophies.* (2019) 4:50. doi: 10.3390/philosophies4030050
11. Sahin O, Salim H, Suprun E, Richards R, MacAskill S, Heilgeist S, et al. Developing a preliminary causal loop diagram for understanding the wicked complexity of the COVID-19 pandemic. *Systems.* (2020) 8:20. doi: 10.3390/systems8020020
12. Oran DP, Topol EJ. Prevalence of asymptomatic SARS-CoV-2 infection. *Ann Intern Med.* (2020) 173:362–367. doi: 10.7326/M20-3012
13. Salem ML, El-Hennawy D. The possible beneficial adjuvant effect of influenza vaccine to minimize the severity of COVID-19. *Med Hypotheses.* (2020) 140:109752. doi: 10.1016/j.mehy.2020.109752
14. Zanettini C, Omar M, Dinalankara W, Imada EL, Colantuoni E, Parmigiani G, et al. Influenza vaccination and COVID19 mortality in the USA. *medRxiv.* (2020) 2020.06.24.20129817. doi: 10.1101/2020.06.24.20129817
15. Fink G, Orlova-Fink N, Schindler T, Grisi S, Ferrer AP, Daubenberger C, et al. Inactivated trivalent influenza vaccine is associated with lower mortality among Covid-19 patients in Brazil medRxiv *[Preprint]*. (2020) 2020.06.29.20142505. doi: 10.1101/2020.06.29.20142505
16. Yaqinuddin A. Cross-immunity between respiratory coronaviruses may limit COVID-19 fatalities. *Med Hypotheses.* (2020) 144:110049. doi: 10.1016/j.mehy.2020.110049
17. Grifoni A, Weiskopf D, Ramirez SI, Mateus J, Dan JM, Moderbacher CR, et al. Targets of T Cell responses to SARS-CoV-2 coronavirus in humans with COVID-19 disease and unexposed individuals. *Cell.* (2020) 181:1489–501. doi: 10.1016/j.cell.2020.05.015
18. Nelde A, Bilich T, Heitmann JS, Maringer Y, Salih HR, Roerden M, et al. SARS-CoV-2-derived peptides define heterologous and COVID-19-induced T cell recognition. *Nat Immunol.* (2020). doi: 10.1038/s41590-020-00808-x
19. Le Bert N, Tan AT, Kunasegaran K, Tham CYL, Hafezi M, Chia A, et al. SARS-CoV-2-specific T cell immunity in cases of COVID-19 and SARS, and uninfected controls. *Nature.* (2020) 584:457–62. doi: 10.1038/s41586-020-2550-z
20. Sekine T, Perez-Potti A, Rivera-Ballesteros O, Strålin K, Gorin J-B, Olsson A, et al. Robust T cell immunity in convalescent individuals with asymptomatic or mild COVID-19. *Cell.* (2020) 183:158–68. doi: 10.1016/j.cell.2020.08.017
21. Ferguson NM, Laydon D, Nedjati-Gilani G, Imai N, Ainslie K, Baguelin M, et al. *Report 9: Impact of Non-Pharmaceutical Interventions (NPIs) to Reduce COVID-19 Mortality and Healthcare Demand*. London. (2020)
22. Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. *Nature.* (2020) 584:257–61. doi: 10.1038/s41586-020-2405-7
23. Klement RJ. *Die Fehlprognosen. Rubikon.* (2020) Available online at: https://www.rubikon.news/artikel/die-fehlprognosen
24. Ioannidis JPA, Cripps S, Tanner MA. Forecasting for COVID-19 has failed. *Int J Forecast.* (2020). doi: 10.1016/j.ijforecast.2020.08.004
25. Ponton F, Wilson K, Cotter SC, Raubenheimer D, Simpson SJ. Nutritional immunology: a multi-dimensional approach. *PLoS Pathog.* (2011) 7:e1002223. doi: 10.1371/journal.ppat.1002223
26. Calder PC, Carr AC, Gombart AF, Eggersdorfer M. Optimal nutritional status for a well-functioning immune system is an important factor to protect against viral infections. *Nutrients.* (2020) 12:1181. doi: 10.3390/nu12041181
27. Alexander J, Tinkov A, Strand TA, Alehagen U, Skalny A, Aaseth J. Early nutritional interventions with zinc, selenium and vitamin D for raising anti-viral resistance against progressive COVID-19. *Nutrients.* (2020) 12:2358. doi: 10.3390/nu12082358
28. Shah A. Novel coronavirus-induced NLRP3 inflammasome activation: a potential drug target in the treatment of COVID-19. *Front Immunol.* (2020) 11:1021. doi: 10.3389/fimmu.2020.01021
29. Alschuler L, Weil A, Horwitz R, Stamets P, Chiasson AM, Crocker R, et al. Integrative considerations during the COVID-19 pandemic. *Explore.* (2020) doi: 10.1016/j.explore.2020.03.007
30. Atherton JG, Kratzing CC, Fisher A. The effect of ascorbic acid on infection of chick-embryo ciliated tracheal organ cultures by coronavirus. *Arch Virol.* (1978) 56:195–99. doi: 10.1007/BF01317848
31. Youm YH, Nguyen KY, Grant RW, Goldberg EL, Bodogai M, Kim D, et al. The ketone metabolite β-hydroxybutyrate blocks NLRP3 inflammasome-mediated inflammatory disease. *Nat Med.* (2015) 21:263–9. doi: 10.1038/nm.3804
32. Alamdari DH, Moghaddam AB, Amini S, Keramati MR, Zarmehri AM, Alamdari AH, et al. Application of methylene blue -vitamin C –N-acetyl cysteine for treatment of critically ill COVID-19 patients, report of a phase-I clinical trial. *Eur J Pharmacol.* (2020) 885:173494. doi: 10.1016/j.ejphar.2020.173494
33. Panarese A, Shahini E. Letter: Covid-19, and vitamin D. *Aliment Pharmacol Ther.* (2020) 51:993–5. doi: 10.1111/apt.15752
34. Ilie PC, Stefanescu S, Smith L. The role of vitamin D in the prevention of coronavirus disease 2019 infection and mortality. *Aging Clin Exp Res.* (2020) 32:1195–8. doi: 10.1007/s40520-020-01570-8
35. Marik PE, Kory P, Varon J. Does vitamin D status impact mortality from SARS-CoV-2 infection? *Med Drug Discov.* (2020) 6:100041. doi: 10.1016/j.medidd.2020.100041
36. Radujkovic A, Hippchen T, Tiwari-Heckler S, Dreher S, Boxberger M, Merle U. Vitamin D deficiency and outcome of COVID-19 patients. *Nutrients.* (2020) 12:E2757. doi: 10.3390/nu12092757
37. Benskin LL. A basic review of the preliminary evidence that COVID-19 risk and severity is increased in vitamin D deficiency. *Front Public Health.* (2020) 8:513. doi: 10.3389/fpubh.2020.00513
38. Castillo ME, Entrenas Costa LM, Vaquero Barrios JM, Alcalá Díaz JF, Miranda JL, Bouillon R, et al. Effect of calcifediol treatment and best available therapy versus best available therapy on intensive care unit admission and mortality among patients hospitalized for COVID-19: a pilot randomized clinical study. *J Steroid Biochem Mol Biol.* (2020) 203:105751. doi: 10.1016/j.jsbmb.2020.105751
39. Iwata M, Ota KT, Li X, Sakaue F, Li N, Dutheil S, et al. Psychological stress activates the inflammasome via release of adenosine triphosphate and stimulation of the purinergic type 2x7 receptor. *Biol Psychiatry.* (2016) 80:12–22. doi: 10.1016/j.biopsych.2015.11.026
40. Guo Q, Zheng Y, Shi J, Wang J, Li G, Li C, et al. Immediate psychological distress in quarantined patients with COVID-19 and its association with peripheral inflammation: a mixed-method study. *Brain Behav Immun.* (2020) 88:17–27. doi: 10.1016/j.bbi.2020.05.038
41. Banks J, Xu X. The mental health effects of the first two months of lockdown and social distancing during the Covid-19 pandemic in the UK. IFS Working Paper W20/16. London. (2020)
42. Majumdar P, Biswas A, Sahu S. COVID-19 pandemic and lockdown: cause of sleep disruption, depression, somatic pain, and increased screen exposure of office workers and students of India. *Chronobiol Int.* (2020) 37:1191–200. doi: 10.1080/07420528.2020.1786107

43. Prousa D. Studie zu psychologischen und psychovegetativen Beschwerden durch die aktuellen Mund-Nasenschutz-Verordnungen in Deutschland. *PsychArchives [Preprint]*. (2020). doi: 10.23668/psycharchives.3135
44. Everts J. The dashboard pandemic. *Dialogues Hum Geogr.* (2020) 10:260–4. doi: 10.1177/2043820620935355
45. Klement RJ, Bandyopadhayay PS. The epistemology of a positive SARS-CoV-2 test. *Acta Biotheor*. (2020) 4:1–17. doi: 10.1007/s10441-020-09393-w
46. Wernike K, Keller M, Conraths FJ, Mettenleiter TC, Groschup MH, Beer M. Pitfalls in SARS-CoV-2 PCR diagnostics. *Transbound Emerg Dis*. (2020). doi: 10.1111/tbed.13684
47. Lee SH. Testing for SARS-CoV-2 in cellular components by routine nested RT-PCR followed by DNA sequencing. *Int J Geriatr Rehabil.* (2020) 2:69–96
48. Seifried J, Böttcher S, Albrecht S, Stern D, Willrich N, Zacher B, et al. Erfassung der SARS-CoV-2-Testzahlen in Deutschland (Stand 2.9.2020). *Epidemiol Bull.* (2020) 36:15–8. doi: 10.25646/7123
49. Bundesregierung Deutschland. "*Nehmen Sie das Virus weiterhin ernst!" (Pressekonferenz von Bundeskanzlerin Merkel am 28. August 2020)*. (2020) Available online at: https://www.bundesregierung.de/breg-de/themen/buerokratieabbau/kanzlerin-sommer-pk-1780768 (accessed September 6, 2020)
50. Bar-Hillel M. The base-rate fallacy in probability judgments. *Acta Psychol.* (1980) 44:211–33. doi: 10.1016/0001-6918(80)90046-3
51. Gigerenzer G, Gaissmaier W, Kurz-Milcke E, Schwartz LM, Woloshin S. Helping doctors and patients make sense of health statistics. *Psychol Sci Public Interes Suppl.* (2007) 8:53–96. doi: 10.1111/j.1539-6053.2008.00033.x
52. Gigerenzer G, Gray JAM. *Better Doctors, Better Patients, Better Decisions. Envisioning Health Care 2020*. 1st ed. Cambridge, MA, London: The MIT Press. (2011). doi: 10.7551/mitpress/9780262016032.001.0001
53. Keil U, Schönhöfer P, Spelsberg A. The invention of the swine-flu pandemic. *Eur J Epidemiol.* (2011) 26:187–90. doi: 10.1007/s10654-011-9573-6
54. World Health Organization. *Voluntary Contributions by Fund and by Contributor, 2018*. (2019) Available online at: https://www.who.int/about/finances-accountability/reports/A72_INF5-en.pdf (accessed May 14, 2020)
55. Wagner E. *The Gates Foundation's Vaccination Activism. Multipolar.* (2020) Available online at: https://multipolar-magazin.de/artikel/the-gates-foundations-vaccination-activism (accessed May 14, 2020)
56. GAVI Alliance. *The Bill & Melinda Gates Foundation.* (2020). Available online at: https://www.gavi.org/investing-gavi/funding/donor-profiles/bill-melinda-gates-foundation (accessed October 10, 2020).
57. Klement RJ. The SARS-CoV-2 crisis: a crisis of reductionism? *Public Health.* (2020) 185:70–1. doi: 10.1016/j.puhe.2020.06.019
58. Walach H. Brainmasks – how the Covid19-Crisis generates new narratives. *SSRN Electron J [Preprint]*. (2020). doi: 10.2139/ssrn.3608584
59. Ray D, Subramanian S. India's lockdown: an interim report. *Ind Econ Rev*. (2020). doi: 10.1007/s41775-020-00094-2
60. Mensi C, De Matteis S, Catelan D, Dallari B, Riboldi L, Pesatori AC, et al. Geographical patterns of mesothelioma incidence and asbestos exposure in Lombardy, Italy. *Med Lav.* (2016) 107:340–55.
61. Armocida B, Formenti B, Ussai S, Palestra F, Missoni E. The Italian health system and the COVID-19 challenge. *Lancet Public Heal.* (2020) 5:e253. doi: 10.1016/S2468-2667(20)30074-8
62. Klement RJ. The SARS-CoV-2 crisis: has medicine finally entered a reductionist era? *Complement Med Res.* (2020) 27:207–8. doi: 10.1159/000510453
63. Wieland T. A phenomenological approach to assessing the effectiveness of COVID-19 related nonpharmaceutical interventions in Germany. *Saf Sci.* (2020) 131:104924. doi: 10.1016/j.ssci.2020.104924
64. Atkeson AG, Kopecky K, Zha T. *Four Stylized Facts About COVID-19*. Cambridge, MA. (2020) Available online at: http://www.nber.org/papers/w27719
65. Miles D, Stedman M, Heald A. Living with COVID-19: balancing costs against benefits in the face of the virus. *Natl Inst Econ Rev.* (2020) 253:R60–R76. doi: 10.1017/nie.2020.30

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Evaluating Training Need for Epidemic Control in Three Metropolitans: Implications for COVID-19 Preparedness in Vietnam

Diep Ngoc Nguyen[1,2], Huong Thi Le[3], Phong Khanh Thai[4], Xuan Thi Thanh Le[3], Men Thi Hoang[1,2], Linh Gia Vu[5], Toan Thi Thanh Do[3], Khanh Nam Do[3], Giap Van Vu[6,7], Tu Huu Nguyen[8], Thanh Tuan Le[9], Trung Dinh Tran[10], Dat Van Truong[11], Cuong Duy Do[12], Thu Ha Nguyen[3], Dung Tri Phung[13], Son Hong Nghiem[14], Thuc Thi Minh Vu[3], Bach Xuan Tran[3,15], Carl A. Latkin[15], Roger C. M. Ho[16,17] and Cyrus S. H. Ho[18]*

[1] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [2] Faculty of Pharmacy, Duy Tan University, Da Nang, Vietnam, [3] Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [4] Queensland Alliance for Environmental Health Sciences (QAEHS), The University of Queensland, Brisbane, QLD, Australia, [5] Center of Excellence in Evidence-Based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam, [6] Department of Internal Medicine, Hanoi Medical University, Hanoi, Vietnam, [7] Respiratory Center, Bach Mai Hospital, Hanoi, Vietnam, [8] Vietnam Young Physicians' Association, Hanoi, Vietnam, [9] Vietnam National Heart Institute, Bach Mai Hospital, Hanoi, Vietnam, [10] Faculty of Public Health, Danang University of Medical Technology and Pharmacy, Da Nang, Vietnam, [11] Faculty of Pharmacy, University of Medicine and Pharmacy at Ho Chi Minh City, Ho Chi Minh City, Vietnam, [12] National Hospital of Tropical Diseases, Bach Mai Hospital, Hanoi, Vietnam, [13] School of Medicine, Griffith University, Gold Coast Campus, Southport, QLD, Australia, [14] Centre for Applied Health Economics (CAHE), Griffith University, Brisbane, QLD, Australia, [15] Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, United States, [16] Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore, [17] Institute for Health Innovation and Technology (iHealthtech), National University of Singapore, Singapore, Singapore, [18] Department of Psychological Medicine, National University Hospital, Singapore, Singapore

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***Correspondence:**
Diep Ngoc Nguyen
nguyenngocdiep7@duytan.edu.vn

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Upon the outbreak of the COVID-19 pandemic, countries worldwide face a critical shortage of human resources in the health sector. Medical students are a potential task force with the capability to support the stretched health sector. This study aims to evaluate their training need for epidemic control in order to employ them effectively. A cross-sectional study was conducted using a web-based survey from December 2019 to February 2020. There were 5,786 observations collected using the snowball sampling technique. Logistic regression was applied to identify factors associated with training participation in epidemic prevention and disaster prevention. Multiple Poisson regression model was constructed to examine factors associated with the number of times they participated in sanitation training and disaster prevention activities in the previous 12 months. Sanitation and health education communication activities had the highest proportion of participants, with 76.5 and 38.4%, followed by examining and treating diseases in the community (13.4%). Those who participated in community activities had a higher number of times to participate in epidemic sanitation training and be involved in disaster prevention. This study informed the need for training programs to prepare medical students for COVID-19 epidemic responses. The training curriculum should include both theoretical approaches and contextual approaches to achieve efficient epidemic control.

Keywords: COVID-19, infection, medical students, epidemic control, training need

INTRODUCTION

COVID-19 is the infectious disease caused by a new coronavirus that was first reported from Wuhan, China, on 31 December 2019. The World Health Organization (WHO) has officially declared the outbreak of COVID-19 pandemic on 11 March 2020, after the disease caused by the new coronavirus spread to more than 100 countries and led to tens of thousands of cases within a few months. With more than 200 countries, areas, or territories with positive cases of COVID-19, social distancing has been applied in most countries to minimize the spread of the virus. Washing of hands frequently, routine cleaning of frequently touched surfaces, and, more recently, wearing of face mask/covering are the additional methods recommended by health authorities to slow down the spread of the virus. Recent COVID-19 research found that these precautional measures safeguard well-being at the COVID-19 outbreak (1) and peak of epidemics (2). Because COVID-19 is a completely new epidemic, governments in different countries have taken different approaches to control this epidemic in their countries. The UK government, for instance, had briefly considered the "herd immunity" approach but quickly had to admit that, with COVID-19, the health impact, including the mortality rate, would be phenomenal (3, 4). Other countries such as Taiwan, Singapore, and Vietnam chose to apply strict measures at the early stages of the outbreak rate such as forced isolation, social distancing, and strict quarantine and contact tracing rules. Those strict measures help those countries to keep the numbers of COVID-19 cases low but require extra human resources, especially well-trained preventive medicine staff that could lead to a shortage in many countries during this epidemic period.

Vietnam belongs to the low- and middle-income country (LMIC) group whose water, safety, and hygiene in healthcare facilities need to be improved. According to State Party Self-Assessment Annual Reporting 2018, the average scores of indicator groups, including points of entry, national health emergency framework, and surveillance, were quite low in Vietnam (40/100, 47/100, and 50/100, respectively) (5, 6). Vietnam achieved a medium score in human resources indicators (60/100), indicating a great potential in its human resources. As mentioned above, Vietnam was considered among countries that performed well in preventing the spread of coronavirus in the community. The government has immediately applied timely policies as well as informed the residents about the perception of using masks and other risks with the considerable contribution of social media and science journalism (7–11). Notwithstanding these timely actions, the government has mobilized the entire health sector, including medical students, to participate in epidemic control, and the Ministry of Health of Vietnam has called on medical students to help in the fight against the epidemic to enhance human resources (12–14).

In previous epidemics such as SARS, H5N1, and AIDS, the great contribution of medical students in preventing and controlling the disease has been recognized in Canada, Hong Kong, and Turkey. Medical students are important human resources that might have the capability to support the community, with their advantages of youth, skills, and knowledge, in the fight against an epidemic (15–17). Despite their confidence and willingness to contribute, an important lesson is to ensure preparedness and awareness among medical students who are directly involved in epidemic control because of their specific roles. In terms of COVID-19 epidemic, the process of medical student education is reconsidered to evaluate whether these students have the required preparedness to participate in the fight against the deadly coronavirus (18, 19).

The spread of COVID-19 around the world has shown that metropolitans have the highest risk of overwhelming spreading due to high population density and social activities. Fortunately, the metropolitans in Vietnam are also where most of the medical students are. In the three high-risk metropolitans of Vietnam, i.e., Hanoi, Da Nang, and Ho Chi Minh City (the three largest cities), most medical students have participated in a training of epidemic prevention and support, but there has been a limited assessment of the training process and the appropriateness of the training program. Therefore, during the unanticipated epidemic of COVID-19, this study aims to figure out whether medical students have received appropriate training for epidemic control and the associated factors that affected their training and practices.

MATERIALS AND METHODS

Study Design and Sampling Methods

A cross-sectional study was conducted using a web-based survey named SurveyMonkey®. SurveyMonkey is one of most common platforms for online survey because it is intuitive and easy to share. The system provides the ability to develop questionnaires with a variety of question types and is easy for researchers to modify. At the same time, the confidentiality of the collected information is also guaranteed by passwords and a privacy system. Using this platform, research was ably conducted on a large scale in Vietnam in a short time. The reason for time limitation was because this study was a sub-analysis of a project on medical workers and medical students during the initial period of the COVID-19 epidemic when the assessment of national responses was vital. Data were collected from December 2019 to February 2020 in Vietnam, which covered the period from the very first COVID-19 cluster that was reported in Wuhan, China, on 31 December 2019 until the outbreak was declared a public health emergency of international concern by WHO on 30 January 2020 but before WHO declared the outbreak as an epidemic on 11 March 2020.

The participants were medical students in different medical universities in Vietnam who met the following inclusion criteria: (1) at least 18 years old, (2) currently living in Vietnam, (3) agreeing to participate in the survey by providing an online informed consent, and (4) having the ability to read and respond to the questionnaire.

In order to avoid having participants answer the survey more than once, no material incentives were given to the participants for their engagement of the survey. In total, there were 5,786 observations that can be used for analysis.

We applied the "snowball sampling technique" to recruit participants. Several core groups of medical students from

the Vietnam Young Physician Association, Vietnam Youth Federation, and medical universities in Hanoi, Danang, and Ho Chi Minh City have been centered upon at the beginning of the recruitment process. The core groups sent the link to students of medical universities in other provinces in three regions of North, Central, and South Vietnam for them to access the questionnaire. The students who had been involved in the study were instructed to invite other students to join because they were more likely to know other people who have similar background characteristics and are suitable to be involved in the survey. One person could easily send the link of survey *via* weblink, email, social network, and messenger apps to others.

Variables

Socioeconomic Characteristics

The participants provided information about their gender, age, specialty, marital status, and living areas.

Training and Practice for COVID-19 Epidemic Control Among Medical Students

The participants were asked if they attended training classes in epidemic prevention and disaster prevention and if they have ever been involved in disaster prevention. They self-reported community activities that they had participated in. They were also asked about the number of times that they participated in environmental sanitation training in the previous 12 months as well as were involved in disaster prevention. Moreover, the participants were asked whether they agree with the importance of the following local hygiene and disease prevention measures:

- Early prevention, environmental sanitation, and population health improvement
- Mobilization of community participation in disease control
- Training on up-to-date scientific knowledge
- Raising awareness of the impacts of climate change
- Ensuring adequate budget for disease prevention
- Periodic surveillance for infectious diseases
- Strengthening health communication and education programs
- Development of epidemic forecast systems to provide early warning
- Improvement of interdisciplinary scientific research capacity
- Workforce support for preventive medicine sectors
- Development of guidelines for disease prevention
- Increasing coordination among local actors.

Statistical Methods

STATA software was used to analyze the final data. Mean and standard Deviation (SD) were described for quantitative variables; frequency and percentage were used to describe qualitative variables. The differences between these variables were tested using Kruskal–Wallis test and chi-square test, depending on each variable. $P < 0.05$ was considered statistically significant. Logistic regression was applied to identify factors associated with training participation in epidemic prevention and disaster prevention. A multiple Poisson regression model was constructed to examine the factors associated with the number of times that they participated in sanitation training and disaster prevention activities in the previous 12 months. The independent variables included in the model were socioeconomic status and the specialty of the participants. Forward stepwise selection was used to construct the reduced model that only contained independent variables having a log-likelihood ratio test $p < 0.2$.

Ethical Consideration

The Scientific Council of Vietnam Central Youth Union has reviewed and approved this study protocol (No. 85 QĐ/TWĐTN-VNCTN).

RESULTS

Table 1 shows that there were 74.9% female medical students, about three times higher than the 25 male medical students (25.1%). The average age of the medical students was 20.6 years (SD = 1.7), and 98.5% among them were single. The rate of living in urban and rural areas was 87.7 and 12.3%, respectively.

Table 2 indicates that 87.6% of the medical students have attended training classes on hygiene in epidemic prevention and disaster prevention, and 91.6% of them were involved in disaster prevention with average number of times of 1.0 (SD = 1.4) and 1.1 (SD = 1.0) for each type of activity, respectively. Environment sanitation and health education communication are two learning topics that have the highest proportion of attendance among the participants at 76.5 and 38.4%, followed by examining and treating diseases in the community (13.4%). However, the remaining learning topics have relatively low rates of participants: mobilize community participation (11.5%), support for life and social security in the locality (7.4%), detect and notify epidemics/natural disasters (3.1%), and control and isolate affected areas (2.0%).

Table 3 demonstrates the proportion of agreement on the importance of local hygiene and disease prevention measures among the participants. Early prevention, environmental sanitation, and population health improvement was the most common choice by medical students (36.5%), followed by mobilization of community participation in disease control (32.9%) and training on up-to-date scientific knowledge (32.5%).

Table 4 presents the associated factors with training and practice for epidemic control. It can be seen that the medical students who had participated in community activities have a higher number of times to participate in epidemic sanitation training (Coef. = 0.22, 95% CI = 0.09; 0.35) and be involved in disaster prevention (Coef. = 0.21, 95% CI = 0.17; 0.24) compared with those who did not.

DISCUSSION

The findings of our study indicated that the medical students who had participated in community activities were likely to participate in training classes on environmental sanitation for epidemic prevention and be involved in disaster prevention; however, only nearly half of them did actually participate in these activities. Moreover, the rate of students involved in training is high, but the frequency of the training time was only about once per year,

TABLE 1 | Socioeconomic characteristics of medical students.

	Medical specialist		General doctor		Pharmacist		Others		Total		*p*-value
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Total	2,019	34.9	1,189	20.6	1,198	20.7	1,380	23.9	5,786	100.0	
Gender											
Male	589	29.2	338	28.4	320	26.7	205	14.9	1,452	25.1	<0.01[a]
Female	1,429	70.8	851	71.6	878	73.3	1,175	85.1	4,333	74.9	
Living area											
Urban	1,782	88.8	1,039	88.1	1,056	88.6	1,161	85.1	5,038	87.7	0.01[a]
Rural	225	11.2	141	12.0	136	11.4	204	15.0	706	12.3	
Marital status											
Single	1,985	98.4	1,173	98.8	1,178	98.7	1,355	98.2	5,691	98.5	0.57[a]
Others	32	1.6	14	1.2	16	1.3	25	1.8	87	1.5	
Region											
Northern	276	14.1	495	42.9	171	14.6	537	39.9	1,479	26.2	<0.01[a]
Central	117	6.0	58	5.0	82	7.0	45	3.3	302	5.4	
South	1,570	80.0	601	52.1	920	78.4	765	56.8	3,856	68.4	
Participated in community activities											
Yes	885	43.9	525	44.2	455	38.1	555	40.3	2,420	41.9	<0.01[a]
No	1,131	56.1	663	55.8	739	61.9	823	59.7	3,356	58.1	
Age group											
Under 20	602	31.8	291	26.2	338	29.7	610	46.9	1,841	33.8	<0.01[a]
20 and above	1,290	68.2	821	73.8	802	70.4	692	53.2	3,605	66.2	
Age, mean (SD)	20.8	(1.9)	20.7	(1.5)	20.6	(1.6)	20.1	(1.8)	20.6	(1.7)	<0.01[b]

[a] *Chi-square test.*
[b] *Kruskal–Wallis test.*

TABLE 2 | Training and practice for epidemic control among medical students.

	Medical specialist		General doctor		Pharmacist		Others		Total		*p*-value
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Attend training classes on hygiene in epidemic prevention and disaster prevention	1,771	87.7	1,033	86.9	1,058	88.3	1,204	87.3	5,066	87.6	0.73[a]
Involved in disaster prevention	1,839	91.1	1,102	92.7	1,111	92.7	1,249	90.5	5,301	91.6	0.09[a]
Activities of cleaning epidemic rooms in the community	1,330	72.3	835	75.8	917	82.5	975	78.1	4,057	76.5	<0.01[a]
Environmental sanitation											
Health education communication	795	43.2	450	40.8	355	32.0	436	34.9	2,036	38.4	<0.01[a]
Examining and treating diseases in the community	310	16.9	135	12.3	122	11.0	141	11.3	708	13.4	<0.01[a]
Mobilize community participation	206	11.2	137	12.4	141	12.7	125	10.0	609	11.5	0.15[a]
Support for life and social security in the locality	149	8.1	76	6.9	103	9.3	66	5.3	394	7.4	<0.01[a]
Detect and notify epidemics/natural disasters	60	3.3	48	4.4	29	2.6	27	2.2	164	3.1	0.02[a]
Control and isolate affected areas	39	2.1	28	2.5	25	2.3	14	1.1	106	2.0	0.07[a]
Number of times participating in epidemic sanitation training (per year), mean (SD)	1.1	1.4	1.0	1.4	0.9	1.4	0.9	1.3	1.0	1.4	0.43[a]
Number of times involved in disaster prevention (per year), mean (SD)	1.3	1.0	1.2	1.0	0.9	1.0	0.9	0.8	1.1	1.0	0.01[b]

[a] *Chi-square test.*
[b] *Kruskal–Wallis test.*

which is relatively low. Medical students need to be trained more in epidemic control in order to respond to all its aspects and enhance their supporting capability.

The majority of medical students were well-trained in environmental sanitation and health education communication and had basic knowledge about common diseases. The remaining

TABLE 3 | Agreement on the importance of local hygiene and disease prevention measures.

	Medical specialist		General doctor		Pharmacist		Others		Total		*p*-value
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	
Early prevention, environmental sanitation, and population health improvement	744	36.9	392	33.0	480	40.1	494	35.8	2,110	36.5	<0.01[a]
Mobilization of community participation in disease control	662	32.8	365	30.7	407	34.0	470	34.1	1,904	32.9	0.25[a]
Training on up to date scientific knowledge	708	35.1	318	26.8	410	34.2	443	32.1	1,879	32.5	<0.01[a]
Raising awareness on the impacts of climate change	635	31.5	317	26.7	390	32.6	416	30.1	1,758	30.4	0.01[a]
Ensuring adequate budget for disease prevention	595	29.5	288	24.2	387	32.3	400	29.0	1,670	28.9	<0.01[a]
Periodic surveillance for infectious diseases	605	30.0	297	25.0	355	29.6	411	29.8	1,668	28.8	0.01[a]
Strengthening health communication and education programs	571	28.3	283	23.8	330	27.6	395	28.6	1,579	27.3	0.02[a]
Development of epidemic forecasts systems to provide early warning	545	27.0	274	23.0	327	27.3	370	26.8	1,516	26.2	0.05[a]
Improvement of interdisciplinary scientific research capacity	550	27.2	250	21.0	323	27.0	349	25.3	1,472	25.4	<0.01[a]
Workforce support for preventive medicine sectors	545	27.0	243	20.4	311	26.0	357	25.9	1,456	25.2	<0.01[a]
Development of guidelines for disease prevention	519	25.7	246	20.7	303	25.3	344	24.9	1,412	24.4	0.01[a]
Increasing coordination among local actors	510	25.3	236	19.9	275	23.0	342	24.8	1,363	23.6	<0.01[a]

[a]*Kruskal–Wallis test.*

TABLE 4 | Associated factors with training and practice for epidemic control among medical students.

	Attend training classes on hygiene in epidemic prevention and disaster prevention[a]		Number of times participating in epidemic sanitation training (per year)[b]		Involved in disaster prevention[a]		Number of times involved in disaster prevention (per year)[b]	
	OR	95% CI	Coef.	95% CI	OR	95% CI	Coef.	95% CI
Gender (female vs. male)			−0.11	−0.28, 0.06			−0.06***	−0.11, −0.02
Marital status (living with spouse vs. single)			0.28*	−0.03, 0.60	2.26	0.71, 7.23		
Age group (20 and above vs. under 20)			−0.13**	−0.26, −0.00	1.14	0.93, 1.40		
Participated in community activities (yes vs. no)	0.88	0.74, 1.03	0.22***	0.09, 0.35	1.46***	1.19, 1.79	0.21***	0.17, 0.24
Region (vs. Northern)								
Central	0.71*	0.49, 1.03						
South	0.83*	0.68, 1.01			1.19	0.96, 1.47		
Specialty (vs. medical specialist)								
General doctor					1.25*	0.96, 1.62		
Pharmacist			−0.20**	−0.37, −0.03	1.24	0.96, 1.60		
Others			−0.14*	−0.29, 0.00			−0.08***	−0.12, −0.04
Agreement on the importance of local hygiene and disease prevention measures (yes vs. no)								
Development of epidemic forecast systems to provide early warning							−0.04	−0.10, 0.02
Ensuring adequate budget for disease prevention							0.06**	0.01, 0.11
Workforce support for preventive medicine sectors							0.07**	0.01, 0.13
Increasing coordination among local actors					1.86***	1.42, 2.44		

****p < 0.01, **p < 0.05, *p < 0.1.*
[a]*Multivariate logistic regression.*
[b]*Multivariate Poisson regression.*

practical activities (including mobilizing the community, supporting for life and social security in the locality, detecting, and notifying epidemics/natural disasters, and controlling and isolating affected areas) are also necessary for epidemic control. However, the rate of students' attendance in these training topics was low. It is suggested that the training program could be improved to help the students acquire all necessary knowledge to control the epidemic effectively.

Despite the fact that most medical students in Vietnam were not fully equipped with epidemic control training, during the COVID-19 epidemic, Vietnamese medical students have provided important assistance for the healthcare team in the following tasks: (1) assisting passengers in filling the health declaration forms (quarantine task), (2) assisting Center for Disease Control's (CDC) staff in tracing incidences of COVID-19 and people related to patients, (3) setting up genealogy maps to monitor the spread of the disease, (4) helping CDC's team to investigate the epidemic by tracking people who pose a high risk of transmission, (5) taking samples for testing for the virus, (6) quarantining suspected patients and assisting doctors and nurses, and (7) promoting preventive measures in the communities (20). Since the worldwide outbreak of COVID-19, in order to make these tasks more efficient, Vietnam has implemented timely interventions such as posting anti-epidemic guides through the webpage of medicine and pharmacy universities (including video clips, e-documents, updated news) as well as the mobile app NCOVI from the government portal that provided instructions for coronavirus disease prevention (21–25).

Even in more developed countries, the preparedness of medical students was also not high as they are perceived as non-frontline staff (26) and have lower resilience (27). A study in the United States reported that 98.5% of undergraduate students received quite poor health education communication (28). Findings from a study in England also pointed out the gap in public health and epidemiology training curriculum, and reformation to improve the training for medical students has been started (29). In the LMIC group, 86% of Pakistan medical students were not satisfied with the epidemiology approach at the university (30). In a Malaysian medical university, 84.6% of students believed that there should be more practical sessions (31). Medical universities in Vietnam previously assessed the importance of epidemiology and the training needs (32–35); however, the development in training programs has not been shown in our results yet.

The findings of this study help us draw up some potential implications. While this study indicated that the medical students in Vietnam had enough knowledge in environmental sanitation, health education communication, and common diseases through training in universities and community activities, it revealed, however, the necessity of training in other aspects including mobilizing the community, supporting for life and social security in the locality, detecting and notifying epidemics/natural disasters, and controlling and isolating affected areas. To deliver the knowledge of epidemic control to students, there are possible methods such as on-site training, e-learning, integrating with official training curriculums in the university, and developing instruction materials (36–41). Nevertheless, training programs should include theoretical approaches (e.g., pathogens, critical treatments) as well as other contextual approaches to achieve efficient epidemic control in each region. Training curriculum could be built based on the diversification of cultures to help the trainees be closer to the residents and meet expected outcomes in preventing and controlling the epidemic (42, 43), and after these classes, the trainees, including medical students, should have a higher level of awareness and preparedness on epidemic control. There was insufficient evidence about the customs and the colloquialisms of each population in epidemic control training programs. For example, current official online training documents of WHO have not identified customary risks yet (44). Therefore, medical staff at the grassroots level might meet difficulties in implementing solutions for public health approaches in epidemic response and system thinking in epidemic response. Further studies should assess customary characteristics in order to help medical staffs detect the risks at multilevel approaches.

Nonetheless, we acknowledge some limitations of our study. First, using the snowball sampling method might lessen the representability of our study. In return, our findings are urgent and consistent with the urgent requirements of the epidemic situation in Vietnam. Secondly, the self-reported data collection might lead to recall bias. A minor limitation in this study was the fact that the number of females was significantly higher than that of males. However, the results after dividing the variables by gender showed that there were very few variables which indicated a statistically significant difference between males and females. Finally, the cross-sectional study design might limit the possibility to identify causal relationships. Several questions remain unanswered at present about the training need among other population groups about epidemic control.

CONCLUSIONS

Medical students are important human resources for the healthcare system in the period of health crisis. Indeed thousands of Vietnamese medical students have participated in the fight against COVID-19 epidemic. Although the country has been successful in controlling the virus, our study suggested that the participation of medical students could be more effective if there was more training about epidemic control among them to fill the gap in their training need. The results of our study provided evidence for reforming the training programs for epidemic control to prepare the medical students for COVID-19 epidemic responses in Vietnam. The training curriculum should include both theoretical approaches (e.g., pathology and critical treatments) as well as other contextual approaches to achieve efficient epidemic control in specific regions.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The Scientific Council of Vietnam Central Youth Union. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

BT, RH, and CH conceptualized this work. XL, GV, SN, and TV contributed to data curation. MH contributed to formal analysis. BT contributed to funding acquisition. DN, LV, TD, KD, TuN, DT, and CD contributed to the investigation. XL, DP, and SN contributed to the methodology. BT took charge of project administration and supervision. ThN contributed to resources. TL and TT took charge of software. CL, RH, and CH contributed to validation. DN contributed to writing the original draft. BT, PT, CL, RH, and CH reviewed and edited the manuscript. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *Int J Environ Res Public Health*. (2020) 17:1729. doi: 10.3390/ijerph17051729
2. Wang C, Pan R, Wan X, Tan Y, Xu L, Roger SM, et al. A longitudinal study on the mental health of general population during the COVID-19 epidemic in China. *Brain Behav Immun*. (2020) 87:40–8. doi: 10.1016/j.bbi.2020.04.028
3. O'Grady C. *The U.K. Backed off on Herd Immunity. To Beat COVID-19, We'll Ultimately Need it*. (2020). Available online at: https://www.nationalgeographic.com/science/2020/03/uk-backed-off-on-herd-immunity-to-beat-coronavirus-we-need-it/ (accessed March 20, 2020).
4. Matthews O. *Britain Drops Its Go-It-Alone Approach to Coronavirus*. (2020). Available online at: https://foreignpolicy.com/2020/03/17/britain-uk-coronavirus-response-johnson-drops-go-it-alone/ (accessed March 17, 2020).
5. World Health Organization. *IHR State Party Self-Assessment Annual Reporting tool (SPAR) 2018*. (2018). Available online at: https://extranet.who.int/sph/news/ihr-self-assessment-annual-reporting-tool-spar-2018 (accessed October 26, 2018).
6. World Health Organization, United Nations Children's Fund. *Water, Sanitation and Hygiene in Health Care Facilities: Status in Low and Middle Income Countries and Way Forward*. Geneva: WHO (2015).
7. Huynh TLD. "If You Wear a Mask, Then You Must Know How to Use It and Dispose of It Properly!": a survey study in Vietnam. *Rev Behav Econom*. (2020) 7:145–58. doi: 10.1561/105.00000121
8. Huynh TLD. The COVID-19 containment in Vietnam: what are we doing? *J Glob Health*. (2020) 10:010338. doi: 10.7189/jogh.10.010338
9. La VP, Pham TH, Ho MT, Nguyen MH P, Nguyen KL, et al. Policy response, social media and science journalism for the sustainability of the public health system amid the COVID-19 outbreak: the vietnam lessons. *Sustainability*. (2020) 12:2931. doi: 10.3390/su12072931
10. Huynh TLD. Does culture matter social distancing under the COVID-19 pandemic? *Saf Sci*. (2020) 130:104872. doi: 10.1016/j.ssci.2020.104872
11. Huynh TLD. The COVID-19 risk perception: a survey on socioeconomics and media attention. *Econ Bull*. (2020) 40:758–64.
12. Vietnam News. *Medical Students Pitch in to Fight COVID-19*. (2020). Available online at: https://vietnamnews.vn/society/654099/medical-students-pitch-in-to-fight-covid-19.html (accessed March 25, 2020).
13. Tuoi Tre, News. *Vietnam Calls Up Medical Students, Retired Doctors in Coronavirus Fight*. (2020). Available online at: https://tuoitrenews.vn/news/society/20200322/vietnam-calls-up-medical-students-retired-doctors-in-coronavirus-fight/53614.html (accessed March 22, 2020).
14. IDN. *Vietnam Insider 90,000 Vietnamese Doctors are Ready for Covid-19 Battle*. Ho Chi Minh City: Vietnam Insider (2020).
15. Mak KK, Yiu YF, Ko KL, Hui KS, Mak KM, Mak LY, et al. Attitudes and perceptions of influenza vaccination among Hong Kong doctors and medical students before the 2009 pandemic. *Eur J Public Health*. (2013) 23:257–62. doi: 10.1093/eurpub/cks014
16. Akan H, Gurol Y, Izbirak G, Ozdatli S, Yilmaz G, Vitrinel A, et al. Knowledge and attitudes of university students toward pandemic influenza: a cross-sectional study from Turkey. *BMC Public Health*. (2010) 10:413. doi: 10.1186/1471-2458-10-413
17. Herman B, Rosychuk RJ, Bailey T, Lake R, Yonge O, Marrie TJ. Medical students and pandemic influenza. *Emerging Infect Dis*. (2007) 13:1781–3. doi: 10.3201/eid1311.070279
18. Miller DG, Pierson L, Doernberg S. The role of medical students during the COVID-19 pandemic. *Am Coll Phys*. (2020) 173:145–6. doi: 10.7326/M20-1281
19. Rose S. Medical student education in the time of COVID-19. *JAMA*. (2020) 323:2131–2. doi: 10.1001/jama.2020.5227
20. Vietnamnews. *Youth Actively Support in Prevention of COVID-19 for the Community*. (2020). Available online at: https://vietnamtimes.org.vn/youth-actively-support-in-prevention-of-covid-19-for-the-community-18812.html (accessed April 05, 2020).
21. Danang People's Committee. *Instructions for Coronavirus Prevention*. (2020). Available online at: https://www.danang.gov.vn/web/guest/video?_c=3andid=559 (accessed February 12, 2020).
22. Ministry of Health. *Medical Declaration Through NCOVI Application*. (2020). Available online at: https://vnpt.com.vn/tin-tuc/khai-bao-y-te-qua-ung-dung-ncovi-toan-dan-chung-tay-day-lui-dich-covid-19.html (accessed March 19, 2020).
23. Hue University of Medicine and Pharmacy. *Prevention for COVID-19 Epidemic*. (2020). Available online at: http://bvydhue.com.vn/c186/thong-tin-y-te-.html (accessed March 2020).
24. Can Tho University of Medicine and Pharmacy. (2020). *Prevention for Coronavirus*. Available online at: http://www.ctump.edu.vn/Default.aspx?tabid=2824 (accessed March 2020).
25. Hai Phong University of Medicine and Pharmacy. *Ready Training to Respond to the Covid-19 for Medical Students in Hai Phong City*. (2020). Avaiable online at: http://hpmu.edu.vn/hpmu/news/TIN-TUC-SU-KIEN/Tap-huan-san-sang-tiep-ung-dich-Covid-19-cho-sinh-vien-Y-khi-can-tiep-ung-tren-dia-ban-Thanh-pho-Hai-Phong-2567/ (accessed March 18, 2020).
26. Tan BYQ, Chew NWS, Lee GKH, Jing M, Goh Y, Yeo LLL, et al. Psychological impact of the COVID-19 pandemic on health care workers in Singapore. *Ann Intern Med*. (2020) 173:317–20. doi: 10.7326/M20-1083
27. Ho CS, Chee CY, Ho RC. Mental health strategies to combat the psychological impact of COVID-19 beyond paranoia and panic. *Ann Acad Med Singap*. (2020) 49:155–60.
28. Ury WA, Berkman CS, Weber CM, Pignotti MG, Leipzig RM. Assessing medical students' training in end-of-life communication: a survey of interns at one urban teaching hospital. *Acad Med*. (2003) 78:530–7. doi: 10.1097/00001888-200305000-00019
29. Reis S. Curriculum reform: why? what? how? and how will we know it works? *ISR J Health Policy Res*. (2018) 7:30. doi: 10.1186/s13584-018-0221-4

30. Butt AK, Khan AA. Teaching biostatistics and epidemiology in a postgraduate medical institution: are we going in the right direction? *East Mediterr Health J*. (2008) 14:1192–7.
31. Daher AM, Amin F. Assessing the perceptions of a biostatistics and epidemiology module: views ofYear 2 medical students from a Malaysian university. *a cross-sectional survey. BMC Med Educ*. (2010) 10:34. doi: 10.1186/1472-6920-10-34
32. Fan AP, Tran DT, Kosik RO, Mandell GA, Hsu HS, Chen YS. Medical education in Vietnam. *Med Teach*. (2012) 34:103–7. doi: 10.3109/0142159X.2011.613499
33. Goto A, Phuong NTN, Huong NTM, Hughes J. Building postgraduate capacity in medical and public health research in Vietnam: an in-service training model. *J Public Health*. (2005) 119:174–83. doi: 10.1016/j.puhe.2004.05.005
34. Dao AT, Huong le T, Nguyen HV, Hoat LN. *Epidemiology training needs assessment in Vietnam. Med Educ*. (2010) 44:518–9. doi: 10.1111/j.1365-2923.2010.03660.x
35. Tran BX, Dang AK, Thai PK, Le HT, Le XTT, Do TTT, et al. Coverage of health information by different sources in communities: implication for COVID-19 epidemic response. *J Int J Environ Res Public Health*. (2020) 17:3577. doi: 10.3390/ijerph17103577
36. Dodani S, Songer T, Ahmed Z, Laporte RE. Building research capacity in developing countries: cost-effectiveness of an epidemiology course taught by traditional and video-teleconferencing methods in Pakistan. *Telemed Health*. (2012) 18:621–8. doi: 10.1089/tmj.2011.0262
37. Adam T, Koopmanschap MA, Evans DB. Cost-effectiveness analysis: can we reduce variability in costing methods? *Int J Technol Assess Health Care*. (2003) 19:407–20. doi: 10.1017/S0266462303000369
38. Armstrong T, Bull F. Development of the world health organization global physical activity questionnaire (GPAQ). *J Public Health*. (2006) 14:66–70. doi: 10.1007/s10389-006-0024-x
39. Rosswurm MA, Larrabee JH, Zhang J. Training family caregivers of dependent elderly adults through on-site and telecommunications programs. *J Gerontol Nurs*. (2002) 28:27–38. doi: 10.3928/0098-9134-20020701-07
40. Aggarwal R, Gupte N, Kass N, Taylor H, Ali J, Bhan A, et al. A Comparison of online versus on-site training in health research methodology: a randomized study. *BMC Med Educ*. (2011) 11:37. doi: 10.1186/1472-6920-11-37
41. Pluye P, Potvin L, Denis J. Making public health programs last: conceptualizing sustainability. *Eval Program Plann*. (2004) 27:121–33. doi: 10.1016/j.evalprogplan.2004.01.001
42. McKinn S, Linh DT, Foster K, McCaffery K. Communication between health workers and ethnic minorities in Vietnam. *Health Literacy Res Pract*. (2017) 1:e163–72. doi: 10.3928/24748307-20170629-01
43. Rheinländer T, Samuelsen H, Dalsgaard A, Konradsen F. Hygiene and sanitation among ethnic minorities in Northern Vietnam: does government promotion match community priorities? *Soc Sci Med*. (2010) 71:994–1001. doi: 10.1016/j.socscimed.2010.06.014
44. World Health Organization. *Coronavirus Disease (COVID-19) Training: Online Training*. (2020). Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/training/online-training (accessed March 2020).

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OPINION
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Adherence to Social Distancing Measures for Controlling COVID-19 Pandemic: Successful Lesson From Vietnam

Hoang-Long Vo[1], Hao Anh Si Nguyen[1], Khanh Ngoc Nguyen[1], Huong Lan Thi Nguyen[2,3], Hien Thi Nguyen[2,3], Long Hoang Nguyen[4], Giang Thu Vu[5] and Huong Thi Le[1]*

[1] Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [3] Faculty of Nursing, Duy Tan University, Da Nang, Vietnam, [4] Institute of Health Economics and Technology, Hanoi, Vietnam, [5] Center of Excellence in Evidence-based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam

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****Correspondence:***
Huong Lan Thi Nguyen
nguyentlanhuong5@duytan.edu.vn

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Social distancing measure has been considered an effective policy response across nations to mitigate the spread of the COVID-19 pandemic (1). Given the matter that SARS-CoV-2 transmits via close contact, social distancing requires individuals to keep a distance of at least 6 feet from people who do not belong to their households (1). Vietnam has achieved initial results in flattening the curve and slowing the spread of COVID-19 transmission in the community, which is mainly attributable to a high-level adherence of Vietnamese with social distancing measures, accompanied with contact tracing, mass testing, and mandatory isolation (2).

Social distancing measure had been implemented in Vietnam, a country having a long borderline with China, from a very early phase as one of the precautionary measures since the first case was detected on 22 January (**Figure 1**). On 31 January 2020, the Prime Minister issued the Directive 06/CT-TTg (3) to enforce banning, suspending, or narrowing traditional festivals to limit the crowds of people, as well as temporary disclosure of schools and universities, and promoting the use of face masks in public locations. After controlling successfully the first wave of the COVID-19 outbreak with nearly 20 days without reported cases, on 18 March 2020, Vietnam confronted a great challenge when new local cases with unknown causes of transmission were detected in Hanoi, a metropolitan of Vietnam. Until 31 March 2020, 213 new cases were confirmed, and most of them were asymptomatic. During this period, more strict social distancing measures were implemented, including banning crowds of people with more than ten people as well as requesting closure of nonessential places such as educational institutions or entertainment places, restricting the intercity and intracity movement. On 31 March 2020, the Directive 16/CT-TTg was issued which required nationwide social distancing implementation in 15 days. During this period, 59 new cases of COVID-19 were identified (4); however, since 17 April, Vietnam had confirmed no community transmission despite extensive testing. On 23 April, the Vietnam Government decided to loosen the national lockdown and issued the Directive 19/CT-TTg on 24 April about COVID-19 prevention and control strategies in the "new normal" condition, in which social distancing played a major role (5).

The high compliance of Vietnamese with social distancing measures can be explained in multiple perspectives. In terms of the leadership, initially, after the detection of the first case, the Vietnam government rapidly formed the Task Force for the COVID-19 epidemic under the direction of the Vice Prime Minister. The Task Force members encompassed leaders of ministries, localities, and press representatives, aiming to develop national COVID-19 preventive and control measures. Previous experiences with Severe Acute Respiratory Syndrome (SARS) and H1N1 epidemics

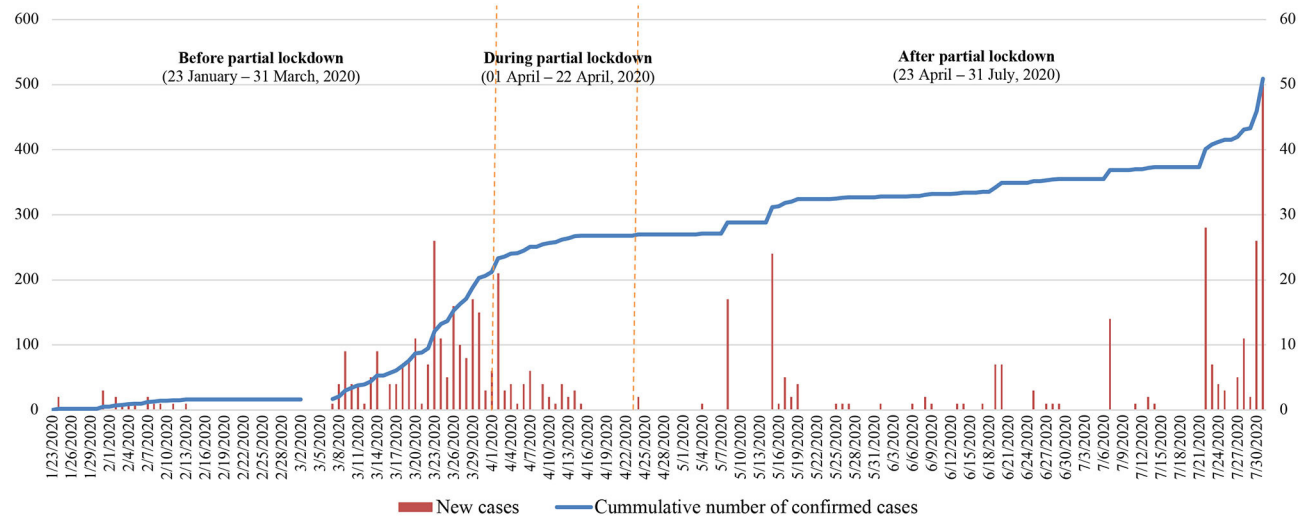

FIGURE 1 | The incidence of confirmed Covid-19 cases and its cumulative numbers, 23 January to 31 July 2020, Vietnam (2).

supported the Task Force to quickly decide the key directions for combating COVID-19, in which social distancing measures had a central role (6). Thus, Directive 06/CT-TTg, Directive 16/CT-TTg, and Directive 19/CT-TTg were issued which underlined the social distancing measure implementation to prevent the spread of COVID-19 by maintaining physical distance and reducing social interactions. Moreover, local authorities issued regulations to guide and enforce social distancing in their community. As per these regulations, people not following social distancing recommendations such as going out in unnecessary cases and fleeing from isolation areas or quarantine facilities have to face administrative sanctions. On the other hand, the government maintained and resuscitated economic activity by encouraging Vietnamese businesses to transition to remote work. A continued support system in the provision of essential services and supplies was suggested by the government, aimed to facilitate adherence to social distancing measures for people and communities. People also received daily messages from the Government via mobile phones or mass media to motivate them to adhere to social distancing. In addition, the government protected people from being exposed to fake news about COVID-19 and the effects of social distancing by providing clear and transparent information about COVID-19 in Vietnam (7).

Adherence to social distancing can also be justified by the attributes of Vietnamese people. Recent evidence from a global survey showed that Vietnamese people were highly satisfied with and believed in the government's measures in the prevention and control of COVID-19 (8). This result might be achieved by various activities of the government as discussed above, including the assurance of essential goods during social distancing, clearing of COVID-19 risk communication, and prompting of actions to control the epidemic. Moreover, the prior experience with severe infectious epidemics (e.g., SARS, H1N1) helped people to understand the importance of social distancing in reducing the transmission rate. On top of that, Vietnamese culture might primarily contribute to the success of the social distancing approach in Vietnam. In fact, Confucianism determines the core values of Vietnamese society regarding different aspects such as philosophy, social organization, culture, and economy (9). This influence embraces the individuals' social responsibilities in protecting the health and life of other people in their community over their freedom or liberties (10), which are much different from Western culture. Living with this ideology facilitated the Vietnamese to respond to the COVID-19 epidemic in a solidarity way, that people altogether adhered to the social distancing to mitigate the impacts of COVID-19 (11).

Despite the more and more increasing global Covid-19 patient number with the overload of the health system, Vietnam has still been responding well to the Covid-19 pandemic with the mobilization of the entire political system. We understand that it is very difficult to implement high-level Covid-19 containment measures in the current phase as in the previous phase. In the "new normal" condition after the national lockdown strategy, one of the biggest future challenges we would like to emphasize is the indifference and subjectivity of the people in the prevention and control of COVID-19. Therefore, all ministries, sectors, organizations, and society from central to local levels need to harmoniously combine administrative and specialized solutions to suggest prompt and efficient actions in the worst-case scenarios in Vietnam.

In resource-constrained settings like Vietnam, strategies to promote aggressive social distancing should be based on the effectiveness analysis of this measure in different locations. The elements from the government and from the public contributing to the good compliance with social distance need to be further assessed to reflect each locality's situation. Importantly, in the "new normal" condition after COVID-19, compliance with social distancing in Vietnam

will be effective when the measures to closely control and monitor repatriation and immigration via its borders are prioritized.

AUTHOR CONTRIBUTIONS

H-LV conceptualized the manuscript. HN reviewed and edited for the final manuscript. All authors synthesized data and related information, wrote the manuscript, and have read and agreed to the published version of the manuscript.

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REFERENCES

1. CDC. *Social Distancing*. (2020) Available online at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/social-distancing.html (accessed July 27, 2020).
2. Pollack T, Thwaites G, Rabaa M, Choisy M, van Doorn R, Luong DH, et al. *Emerging COVID-19 Success Story: Vietnam's Commitment to Containment*. (2020). This article is one of a series focused on identifying and understanding Exemplars in the response to the Coronavirus pandemic. It is hosted by the Exemplars in Global Health (EGH) platform]. Available online at: https://ourworldindata.org/covid-exemplar-vietnam (accessed July 27, 2020).
3. Prime Minister. 06/CT-TTg: Strengthening Preventive and Control. *Measures Against New Complications of Acute Respiratory Infections Caused by New Strains of Corona Virus*. Hanoi (2020).
4. Tuan D. *The Prime Minister agreed to continue implementing Directive 16 at least until April 22 in Some localities Government Electronic Newspaper - Government Portal*. (2020) Available from: http://baochinhphu.vn/Tin-noi-bat/Thu-tuong-nhat-tri-tiep-tuc-thuc-hien-Chi-thi-16-it-nhat-den-224-tai-mot-so-dia-phuong/393140.vgp (accessed July 28, 2020).
5. Vu K, Nguyen P, Pearson J. *After Aggressive Mass Testing, Vietnam Says It Contains Coronavirus Outbreak: Reuters*. (2020) Available online at: https://www.reuters.com/article/us-health-coronavirus-vietnam-fight-insi/after-aggressive-mass-testing-vietnam-says-it-contains-coronavirus-outbreak-idUSKBN22B34H (accessed July 28, 2020).
6. Prime Minister. *Directive No. 16 / CT-TTg of the Prime Minister: On the Implementation of Urgent Measures to Prevent and Combat COVID-19 Epidemic*. Hanoi (2020).
7. Ministry of Health of Vietnam. *Prime Minister: Communication Contributes to the Victory of the COVID-19 Campaign*. (2020) Available online at: https://ncov.moh.gov.vn/-/thu-tuong-truyen-thong-gop-phan-lam-nen-thang-loi-cua-cuoc-chien-chong-dich-covid-19 (accessed July 27, 2020).
8. World Health Organization. *Coronavirus Disease (COVID-19) Advice for the Public*. (2020) Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public (accessed April 12, 2020).
9. Truong TD, Hallinger P, Sanga K. Confucian values and school leadership in Vietnam: Exploring the influence of culture on principal decision making. *Educ Manag Administ Leadership*. (2017) 45:77–100. doi: 10.1177/1741143215607877
10. Hu Y. *Prioritizing Human Rights Helps China Defeat Covid-19*. Experts: Global Times (2020). Available online at: https://www.globaltimes.cn/content/1188066.shtml (accessed July 27, 2020).
11. Huynh TLD. The COVID-19 containment in Vietnam: what are we doing? *J Global Health*. (2020) 10:010338. doi: 10.7189/jogh.10.010338

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Feasibility of Intersectoral Collaboration in Epidemic Preparedness and Response at Grassroots Levels in the Threat of COVID-19 Pandemic in Vietnam

Huong Thi Le[1], Hue Thi Mai[1], Hai Quang Pham[2,3], Cuong Tat Nguyen[2,3], Giang Thu Vu[4], Dung Tri Phung[5], Son Hong Nghiem[6], Bach Xuan Tran[1,7], Carl A. Latkin[7], Cyrus S. H. Ho[8] and Roger C. M. Ho[9,10]*

[1] *Institute for Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam,* [2] *Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam,* [3] *Faculty of Medicine, Duy Tan University, Da Nang, Vietnam,* [4] *Center of Excellence in Evidence-Based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam,* [5] *School of Medicine, Griffith University, Brisbane, QLD, Australia,* [6] *Centre for Applied Health Economics (CAHE), Griffith University, Brisbane, QLD, Australia,* [7] *Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, United States,* [8] *Department of Psychological Medicine, National University Hospital, Singapore, Singapore,* [9] *Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore,* [10] *Institute for Health Innovation and Technology (iHealthtech), National University of Singapore, Singapore, Singapore*

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***Correspondence:**
Hai Quang Pham
phamquanghai@duytan.edu.vn

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To effectively control the COVID-19 (coronavirus disease 2019) outbreak in later stages in Vietnam requires addressing the existing gaps in the national health emergency framework, consolidate, and inform its structure, we conducted this study to evaluate the importance and collaborative mechanism between health and community service workers with intersectional organizations at grassroots levels in Vietnam. A cross-sectional, web-based survey was conducted from 12/2019 to 02/2020 on 581 participants (37 health workers, 473 medical students, and 71 community service workers). The snowball sampling technique was used to recruit participants. We used exploratory factor analysis to test the construct validity of the questionnaire measuring the perceived efficiency of involving community service workers in health care–related activities and Tobit models to examine its associated factors. The results showed the importance of local organizations in epidemic preparedness and response at grassroots levels, with scores ranging from 6.4 to 7.1, in which the Vietnam Youth Federation played the most important role (mean = 7.1, SD = 2.2). Of note, community service workers were viewed as performing well in health communication and education at agencies, schools, and other localities. Medical students perceived higher efficiency of involving community service workers in health care–related activities at grassroots levels as compared to health workers. We encourage the government to promote intersectoral collaboration in epidemic preparedness and response, giving attention to scale up throughout training as well as interdistrict and interprovincial governance mechanisms.

Keywords: COVID-19, intersectoral collaboration, epidemic preparedness, grassroots level, Vietnam

INTRODUCTION

Originating from Hubei province in China, coronavirus disease 2019 (COVID-19) dramatically spread to many parts of the world (1, 2). As of May 11, 2020, there were 4.01 million confirmed cases reported globally, including 88,891 new cases and 278,892 fatal cases, covering 216 countries and territories (3). Understanding the severity and coverage of a pandemic, the World Health Organization has circulated strategic preparedness and response plan for COVID-19 (4). The overall goal of this plan is to stop further COVID-19 transmission and minimize the impacts in all nations. Accordingly, there are three core strategies that can flexibly tailor to a particular context of each country, including (1) establishing international coordination and operational support (2), promoting preparedness and response at the national level, and (3) accelerating research and innovation (4).

While much of the world has recognized the integral role of preparedness and response in the epidemic mitigation, each country has currently developed its own context-specific strategy, which is driven by various factors such as socioeconomic features, health system, and existing resources. Some countries with well-integrated health system and strong human resources, such as the Netherlands and Sweden, have tried to build rapid herd immunity, which occurs when most of the community has become immune to COVID-19 so that it could indirectly protect the community from the infection (5, 6). However, this approach immediately consumes enormous resources and has raised the world concern about its effectiveness because of the drastic increase in the number of COVID-19 cases and deaths in these countries (7). Thus, it perhaps would not be the best-fit model for low-resource settings such as Vietnam, a developing country with a population of more than 100 million people and sharing more than 1,200 km of the border with China.

Instead, Vietnam has currently implemented a strategy of early detection of COVID-19 infection, effective isolation and timely treatment for confirmed cases, and minimizing deaths; at the same time, promoting disease prevention (8, 9). The plan has shown excellent results in the early stages of fighting the COVID-19 epidemic. So far, Vietnam has a much lower number of confirmed cases compared to other neighboring countries, with 239 confirmed cases and no deaths reported by April 2020 (2, 9). However, as the unprecedented and unpredictable spread of COVID-19, it seems to be too early to conclude the successful containment of the outbreak in Vietnam. To maximize the capacity to prevent an uncontrollable outbreak, the existing gaps in the national health emergency framework, as indicated by the Self-Assessment Annual Reporting tool 2018 (10), should be immediately addressed. This requires the quick mobilization of existing resources other than health sectors such as community units and organizations, especially at the grassroots levels where human resources for health are under severe constraints, and the mobilization and management process will be much more effective under the direction of local organizations instead of at the central level (11). In order to consolidate and inform the national health emergency framework, which is responsible for the containment of the outbreak in later stages in Vietnam, we conducted this study to evaluate the importance and collaborative mechanism between health and community service workers with intersectional organizations at grassroots levels in epidemic preparedness and response.

MATERIALS AND METHODS

Study Design and Setting

We conducted a cross-sectional study from 12/2019 to 02/2020 in all provinces of Vietnam via online platforms named SurveyMonkey. SurveyMonkey is one of the most popular online survey sites, due to its intuitive and easy to share. The system allows researchers to create questionnaires with a variety of types of questions and still ensure security by password management system and personal email.

Study Subject

We recruited all health workers, medical students, and community workers through the country if they met the following criteria: (1) being at least 18 years old (2), currently living in Vietnam, and (3) agreeing to participate in the study. Those who were cognitively impaired were excluded from the study. All participants were asked to provide informed consent to confirm their voluntary participation by clicking "agree to participate in the study" after reading the study purposes, their benefits, and responsibilities.

Sampling Procedure and Sample Size

We recruited the exponential non-discriminative snowball sampling technique to recruit respondents using online platforms. This method is considered as a cost-effective, non-probability method that allowed us to locate hidden populations by relying on referrals from one initial respondent to other potential respondents (12). Also, a web-based survey is suitable and effective in the current context, because due to the tremendous impact of the COVID-19 outbreak, people tend to work frequently online; therefore, it allowed us to reach a large number of participants. We sent the questionnaire link to the target participants via email and Facebook. These are the most commonly used online platforms in Vietnam. We recruited 37 health workers, 473 medical students, and 71 community workers. The total sample size was 581 participants.

Study Instruments and Measures

To collect data, we developed a self-reported questionnaire with three main following sections:

Sociodemographic Characteristics

Sociodemographic characteristics included age, gender, living area (urban or rural), marital status (single, married, etc.), education level, having participated in youth association activities, workplace level (central level, provincial level, under provincial level, or working for university).

The Perceived Importance of Community Workers in Health Care, Epidemic Preparedness, and Response at Grassroots Levels

We asked the participants to rate the importance of organizations in health care, epidemic preparedness, and response at grassroots levels. These organizations included the following:

- Ho Chi Minh Communist Youth Union: the largest social–political organization of Vietnamese youth
- Vietnam Youth Federation: broad social organization of Vietnamese youths and youth organizations
- The Vietnamese Fatherland Front: a political coalition organization, a voluntary union of political organizations, sociopolitical organizations, social organizations and individuals representing all classes, social strata, ethnic groups, religions, and overseas Vietnamese
- Viet Nam Farmer's Union: a social–political organization of Vietnamese peasantry
- Viet Nam Women's Union: a sociopolitical organization that represents and defends the legal and legitimate rights and interests of Women in Vietnam
- Local occupational associations: organizations that protect the legal and legitimate rights and interests of their members within the legal framework for a certain profession in the locality
- Religious and belief units: organizations that have the task of regulating, protecting and being the voice of people following different religions, beliefs before the law because Vietnam allows people to freely choose their religion
- Non-governmental organizations: non-profit, citizen-based groups that function independently of government and has an important role to play in supporting resources
- Social businesses: organizations that apply commercial strategies to maximize improvements in financial, social, and environmental well-being.

There were 10 levels of response in each question, with a higher score indicating greater importance.

The Perceived Efficiency of Involving Community Service Workers in Health Care–Related Activities

Participants rated the levels of efficiency of involving community service workers in health care–related activities, including the following: (1) identify the risks of environmental pollution, changes in natural conditions, farming, and unusual weather phenomena; (2) report weather phenomena, pollution risks to the community and authorities; (3) detect and promptly notify disease risks and new cases to the locality; (4) participate in local epidemic prevention and response; (5) participate in health care and improving the health of people who affected by the epidemics, natural disasters such as floods and droughts; (6) guide and support people with abnormal health signs to go to health facilities; (7) participate in health communication and education at agencies, schools, and localities; (8) participate in stabilizing life, livelihood, and local security before, during, and after natural disasters and epidemics. There were 10 levels of response in each question, with a higher score indicating greater efficiency.

Data Management and Analysis

Data were collected by SurveyMonkey and automatically saved in the system. Only approved members could access and export the data. We analyzed data with Stata (version 15, Stata Corp LP, College Station, TX, USA). Quantitative variables were summarized in mean and standard deviation (SD). The differences between these variables were tested using Kruskal–Wallis test, with $p < 0.05$ considered statistically significant. We utilized frequency and percentage to describe qualitative variables. Fisher exact test and χ^2 test were used to test the differences between these variables. We used exploratory factor analysis to explore the construct validity of the questionnaire measuring the perceived efficiency of involving community service workers in health care–related activities. Tobit model was applied to determine factors associated with perceived efficiency of involving community service workers in health care–related activities at grassroots levels. The independent variables, including socioeconomic status, occupation characteristics, and perceived importance of organizations, were entered in the full regression models. The study applied a stepwise forward selection to construct the reduced model that selected variables based on the log-likelihood ratio test at $p < 0.2$.

Ethical Consideration

The study protocol was reviewed and approved by the Scientific Council of Vietnam Central Youth Union (No 177 QĐ/TWĐTN-VNCTN). Participation was completely voluntary, and there were no incentives provided. Collected data were saved in a secured system and only served for the study purposes.

RESULTS

Table 1 summarizes sociodemographic characteristics of respondents. In a total of 581 participants, 37 respondents were health workers, 473 respondents were medical students, and 71 respondents were community service workers. The number of females in the sample was twice that of males (31.2 and 68.9%, respectively). The majority were younger than 25 years (81.4%), lived in the urban (85.7%), were single (85.8%), and participated in community activities. The average age of participants was 22.6 (SD = 5.3) years, and there was a statistically significant difference in age among health workers, medical students, and community service workers ($p < 0.01$).

Table 2 illustrates the perceived importance of organizations in health care, epidemic preparedness, and response at grassroots levels. In general, respondents highly evaluated the importance of organizations in epidemic and response at grassroots levels (mean scores ranged from 6.4 to 7.1). Respondents rated Vietnam Youth Federation (mean = 7.1, SD = 2.2) and Ho Chi Minh Communist Youth Union (mean = 7.0, SD =2.3) as the most important in health care, epidemic preparedness, and response at

grassroots levels. Meanwhile, religious and belief units (mean = 6.4, SD = 2.5) were the least important.

The construct validity of the questionnaire measuring the perceived efficiency of involving community service workers in health care–related activities at grassroots levels is described in **Table 3**. The series of questions were reclassified into two domains called "epidemic investigation, counseling, and control" and "reporting and monitoring environmental changes and health problems." The Cronbach α was very high in both domains (0.95 and 0.91, respectively).

TABLE 1 | Sociodemographic characteristics of respondents.

	Health workers		Medical students		Community service workers		Total		*p*
	n	%	*n*	%	*n*	%	*n*	%	
Total	37	6.4	473	81.4	71	12.2	581	100.0	
Gender									
Male	16	43.2	123	26.0	42	59.2	181	31.2	**<0.01**
Female	21	56.8	350	74.0	29	40.9	400	68.9	
Living area									
Urban	31	83.8	401	86.1	60	84.5	492	85.7	0.89
Rural	6	16.2	65	14.0	11	15.5	82	14.3	
Marital status									
Single	11	29.7	462	98.1	24	33.8	497	85.8	**<0.01**
Living with spouse	26	70.3	1	0.2	44	62.0	71	12.3	
Others	0	0.0	8	1.7	3	4.2	11	1.9	
Workplace									
Central level	5	13.5	52	11.2	16	23.9	73	12.8	**<0.01**
Provincial level	21	56.8	54	11.6	32	47.8	107	18.8	
< Provincial level	9	24.3	4	0.9	19	28.4	32	5.6	
College/university	2	5.4	355	76.3	0	0.0	357	62.7	
Participated in community activities									
Yes	31	83.8	197	41.7	71	100.0	299	51.6	**<0.01**
No	6	16.2	275	58.3	0	0.0	281	48.5	
Age group									
<25 years	3	8.6	448	98.9	3	4.3	454	81.4	**<0.01**
≥ 25 years	32	91.4	5	1.1	67	95.7	104	18.6	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***p***
Age	32.0	6.9	20.5	1.5	32.0	4.8	22.6	5.3	**<0.01**

Table 3 showed the percentage of participants who perceived that the involvement of community service workers in health care–related activities at grassroots levels was highest in "Participate in health communication and education at agencies, schools, and localities" (18%), followed by "guide and support people with abnormal health signs to go to health facilities" (14.2%). In contrast, the percentage of participants who perceived that the involvement of community service workers in health care–related activities at grassroots levels was lowest in "detect and promptly notify disease risks and new cases to the locality" (11.8%), followed by "identify the risks of environmental pollution, changes in natural conditions, farming, and unusual weather phenomena" (12.9%).

As shown in **Table 4**, the mean score of the domain "epidemic investigation, counseling, and control" was 7.3 (SD = 1.8), and in the domain "reporting and monitoring environmental changes and health problems," the mean was 6.9 (SD = 1.9). In the domain, "epidemic investigation, counseling, and control," respondents rated "participate in health communication and education at agencies, schools, and localities" to be the most effective (mean = 7.5, SD = 1.9). In the domain, "reporting and monitoring changes in environment and health," participants rated the highest score for "report weather phenomena, pollution risks to the community and authorities" (mean = 7.1, SD = 2.0).

Table 5 summarizes the results of the regression analysis. Those who lived with spouse tended to perceive the higher efficiency of involving community service workers in epidemic investigation, counseling and control [coefficient = 0.62, 95% confidence interval (CI) = 0.16–1.09], and reporting monitoring changes in environment and health (coefficient = 0.75, 95% CI = 0.16–1.34). Of note, medical students were more likely to perceive the efficiency of involving

TABLE 2 | The perceived importance of organizations in health care, epidemic preparedness, and response at grassroots levels (10-point scale).

	Health workers		Medical students		Community service workers		Total		*p*
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Vietnam Youth Federation	6.1	2.3	7.2	2.1	6.9	2.9	7.1	2.2	**0.03**
Ho Chi Minh Communist Youth Union	6.4	2.6	7.1	2.1	6.8	2.9	7.0	2.3	0.33
The Vietnamese Fatherland Front	5.8	2.7	7.1	2.2	6.8	2.7	7.0	2.3	**0.02**
Viet Nam Farmer's Union:	6.0	2.7	7.1	2.2	6.7	2.7	7.0	2.3	**0.03**
Non-governmental organizations	6.6	2.4	7.0	2.4	6.6	2.4	6.9	2.4	0.32
Social businesses	6.1	2.4	7.0	2.2	6.6	2.5	6.9	2.2	0.05
Viet Nam Women's Union	5.8	2.5	7.1	2.1	6.6	2.8	6.9	2.3	**0.01**
Local occupational associations	5.7	2.5	7.0	2.2	5.9	2.9	6.8	2.4	**<0.01**
Religious and belief units	5.6	2.5	6.6	2.3	5.6	3.1	6.4	2.5	**<0.01**

Bold values indicate significant p-value < 0.05.

TABLE 3 | Factor loadings of the questionnaire measuring the perceived efficiency of involving community service workers in health care–related activities at grassroots levels.

Items	Totally effective		Epidemic investigation, counseling, and control	Reporting and monitoring environmental changes and health problems
	n	%		
(1) Participate in health communication and education at agencies, schools, and localities	104	18.0	0.87	
(2) Guide and support people with abnormal health signs to go to health facilities	84	14.5	0.80	
(3) Report weather phenomena, pollution risks to the community and authorities	82	14.2		0.77
(4) Participate in local epidemic prevention and response	80	13.8	0.69	
(5) Participate in health care and improving the health of people who affected by the epidemics, natural disasters, floods, and droughts	78	13.5	0.84	
(6) Participate in stabilizing life, livelihood, and local security before, during, and after natural disasters and epidemics	75	13.0	0.65	
(7) Identify the risks of environmental pollution, changes in natural conditions, farming, and unusual weather phenomena	75	12.9		0.88
(8) Detect and promptly notify disease risks and new cases to the locality	68	11.8		0.76
Cronbach's α			0.95	0.91
Mean			7.3	6.9
SD			1.8	1.9

TABLE 4 | The perceived efficiency of involving community service workers in health care–related activities at grassroots levels.

Evaluation of respondents on	Medical professional		Medical students		Community workers		Total		*p* value
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Epidemic investigation, counseling, and control	7.0	1.5	7.3	1.7	7.0	2.0	7.3	1.8	0.18
Participate in local epidemic prevention and response	6.9	2.1	7.3	1.9	6.8	2.6	7.2	2.0	0.43
Participate in health care and improving the health of people who affected by the epidemics, natural disasters, floods, and droughts	6.7	1.8	7.3	1.9	7.1	2.3	7.3	1.9	0.14
Guide and support people with abnormal health signs to go to health facilities	7.0	1.7	7.4	1.9	6.8	2.4	7.3	2.0	0.11
Participate in health communication and education at agencies, schools, and localities	7.3	1.7	7.5	1.9	7.5	2.0	7.5	1.9	0.51
Participate in stabilizing life, livelihood, and local security before, during, and after natural disasters and epidemics	7.1	1.8	7.1	1.9	6.8	2.3	7.1	1.9	0.69
Reporting and monitoring environmental changes and health problems	6.2	1.9	7.0	1.8	6.6	2.3	6.9	1.9	**0.02**
Identify the risks of environmental pollution, changes in natural conditions, farming, and unusual weather phenomena	6.3	2.4	6.9	2.1	6.6	2.6	6.9	2.2	0.20
Report weather phenomena, pollution risks to the community and authorities	6.8	2.0	7.1	2.0	6.7	2.3	7.1	2.0	0.31
Detect and promptly notify disease risks and new cases to the locality	5.7	2.3	7.1	1.9	6.4	2.7	6.9	2.1	**<0.01**

Bold values indicate significant p-value < 0.05.

community service workers in reporting and monitoring changes in environment and health compared to health workers (coefficient = 0.75, 95% CI = 0.03–1.06). Of note, those who felt the higher importance of youth associations and social businesses perceived higher efficiency of involving community service workers in epidemic investigation, counseling and control, and reporting and monitoring changes in environment and health.

DISCUSSION

Key Findings

This study evaluated the importance and collaborative mechanism between health and community service workers with intersectional organizations at grassroots levels in epidemic preparedness and response. We found that local organizations were existing resources that could be immediately mobilized to

TABLE 5 | Factors associated with perceived efficiency of involving community service workers in health care–related activities at grassroots levels.

	Epidemic investigation, counseling, and control		Reporting and monitoring environmental changes and health problems	
	Coefficient	**95% CI**	**Coefficient**	**95% CI**
Marital status (living with spouse vs. single)	0.62***	(0.16–1.09)	0.75**	(0.16–1.34)
Objects (vs. health workers)				
Medical students			0.55**	(0.03–1.06)
Community service workers	−0.41*	(−0.87 to 0.04)		
Participated in community activities (yes vs. no)	−0.21	(−0.48 to 0.05)	−0.25*	(−0.53 to 0.02)
Perceived importance of organizations by respondents (10-point scale)				
Vietnam Youth Federation	0.39***	(0.32–0.46)	0.30***	(0.21–0.40)
Local occupation associations			0.12**	(0.03–0.21)
Non-governmental organizations	0.10***	(0.03–0.18)	0.14***	(0.06–0.22)
Social businesses	0.18***	(0.09–0.26)	0.16***	(0.07–0.25)

$^{***}p < 0.01$, $^{**}p < 0.05$, $^{*}p < 0.1$.

address the epidemic; in which youth played a critical role. In the intersectoral mechanism, community service workers were best performed in health communication and education at agencies, schools, and localities. Of note, medical students perceived higher efficiency of involving community service workers in health care–related activities at grassroots levels as compared to health workers.

Facing the COVID-19 pandemic, even the most developed countries may not devote sufficient resources at the initial stages (13), and this situation may be even worse in low and middle developing countries (14). Thus, taking the advantages of on-site resources would be full of potential to scale up country readiness and response operations. In Vietnam, it is a long-held practice that health workers, including doctors, nurses, technicians, and traditional medicine practitioners, pharmacists, are responsible for all health issues of national and international concerns (15). However, overreliance on this specialized taskforce may fail to meet the drastic demand of the population in urgent cases, such as the COVID-19 outbreak. It is advisable, in such situations, to make prudent use of local organizations to ensure a sufficient workforce to respond quickly. In Vietnam, these include the Ho Chi Minh Communist Youth Union, Vietnam Youth Federation, The Vietnamese Fatherland Front, Farmers Association, Women Union, local occupation associations, religious and belief units, non-governmental organizations, and social businesses. These organizations can be actively involved in non–treatment-related activities such as risk communication, health education and surveillance, and aggressive contact tracing. Moreover, as each unit and organization are assigned to a particular task, they may help to inform the response framework and rapid action team at grassroots levels in particular and the national level as a whole.

In the intersectoral mechanism, we found that in Vietnam, the youth should be the priority for mobilization at grassroots levels. In Vietnam, young people aged 15–29 years account for 25% of the total population (16). More importantly, they are better educated (16) and more socially responsible compared to previous generations (17). Thus, in the context of accelerated national and global issues such as infectious disease outbreaks, climate change, and pollution, they could act as the vanguard in community- and social-based activities. At the moment, Vietnam has been mobilized thousands of medical students to support the COVID-19 response with various activities such as epidemiological investigation, quarantine guide, and blood testing (18). It has been critical to systematically scale up youth networks from local to central levels in antiepidemic activities. One of the most feasible tasks, which was indicated in our study, is health communication and education at agencies, schools, and localities. To achieve this, however, requires thorough training and proper interdistrict and interprovincial governance mechanisms.

As reported in our study, medical students perceived higher efficiency of involving community service workers in health-related activities at grassroots levels compared to health workers. Given the core role of medical students in community networks for the epidemic preparedness and response, their perspectives about the efficiency of engaging community service workers in health-related activities are insightful. Thus, it enriches the understanding of the efficiency and feasibility of the collaborative mechanism between health and community service workers with intersectional organizations at grassroots levels in Vietnam.

Limitations

While the study results have provided a valuable contribution to the current understanding of intersectoral collaboration in epidemic preparedness and response at grassroots levels in the threat of COVID-19 pandemic in Vietnam, there are several limitations. An online-based survey may fuel the risks of survey fraud because it did not allow us to confirm participants' identities. To minimize such risks, we did not offer participants with incentives to eliminate the possibility of study participation for incentive purposes. Besides, we used the snowball sampling method, which may introduce sampling bias. This non-probability sampling could affect to the representativeness of the survey sample. Ideally, a

random-sampling technique would minimize this risk; however, it would be costly and, in the current context, infeasible. Third, the study was conducted only in Vietnam, so that the implications would be questioned about their effectiveness and implications when applying in other settings, especially at developed countries. However, based on the fact that Vietnam has achieved outstanding results in COVID-19 prevention and the strength of the time of the study, we believe that these finding can serve as a reference for preparedness and response strategy in other countries.

CONCLUSION

In conclusion, this study indicated the great potential and feasibility of intersectoral collaboration in epidemic preparedness and response at grassroots levels in the threat of COVID-19 pandemic in Vietnam. This approach will not only ensure sufficient resources for urgent cases but also help to inform and shape a determined response framework and rapid action team at the grassroots levels in particular and national levels as a whole. In this intersectoral mechanism, the youth can be the vanguard in community- and social-based activities, especially in health communication and education at localities. To achieve it requires throughout training, interdistrict, and interprovincial governance mechanisms.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by The study protocol was reviewed and approved by the Scientific Council of Vietnam Central Youth Union (No 177 QĐ/TWĐTN-VNCTN). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

HL, GV, and BT designed and supervised the study. HM, HP, and CN collected, analyzed, and interpreted the data. HL, HM, and DP drafted the manuscript. SN, CL, CH, and RH reviewed the manuscript and commented on the writing. All authors agreed with the final manuscript.

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REFERENCES

1. The World Health Organization. *Novel Coronavirus (2019-nCoV)- Situation Report* (21/01/2020).
2. The World Health Organization. *Coronavirus Disease 2019 (COVID-19) Situation Report* (10/04/2020).
3. The World Health Organization. *Coronavirus disease 2019 (COVID-19) Situation Report.* (11/05/2020).
4. The World Health Organization. *2019 Novel Coronavirus (2019-nCOV): Strategic Prepareness and Response Plan* (2020).
5. O'Leary N. Coronavirus: dutch adopt controversial 'herd immunity' strategy. *The Irish Times* (2020).
6. Sweeney S. Coronavirus in Europe: Sweden opts for herd immunity. *Wanted in Europe* (10/04/2020).
7. The World Health Organization. *Coronavirus disease 2019 (COVID-19) Situation Report* (14/04/2020).
8. Ministry of Home Affairs. *Plan No. 1458 / KH-BNV on Responding to Each Stage of COVID-19 Epidemic*. Ministry of Home Affairs (2020).
9. La V-P, Pham T-H, Ho M-T, Nguyen M-H, Nguyen K-L, Vuong T-T, et al. Policy response, social media and science journalism for the sustainability of the public health system amid the COVID-19 outbreak: the vietnam lessons. *Sustainability*. (2020) 12:2931. doi: 10.3390/su12072931
10. The World Health Organization. *Electronic State Parties Self-Assessment Annual Reporting Tool: The World Health Organization*. (2018). Available online at: https://extranet.who.int/e-spar (accessed April 14, 2020).
11. Le D-C, Kubo T, Fujino Y, Pham T-M, Matsuda S. Health care system in Vietnam: current situation and challenges. *Asian Pacific J Disease Manage*. (2010) 4:23–30. doi: 10.7223/apjdm.4.23
12. Johnson TP. Snowball Sampling: Introduction. *Wiley StatsRef: Statistics Reference Online*. American Cancer Society (2014).
13. European Centre for Disease Prevention and Control. Coronavirus disease 2019 (COVID-19) pandemic: increased transmission in the EU/EEA and the UK – seventh update. Stockholm: ECDC: (25/03/2020).
14. Rohwerder B. Secondary impacts of major disease outbreaks in low- and middle- income countries (2020). p. 25.
15. The World Health Organization. *Human resources for health country profiles: Viet Nam* (2016).
16. The OECD Development Centre. *Youth Well-being Policy Review of Viet Nam*. EU-OECD Youth Inclusion Project, Paris (2017). Available online at: http://www.oecd.org/countries/vietnam/OECDYouthReportVietNam_ebook.pdf.
17. Nguyen Tuan Anh. *Youth's Perspective of Social Responsibility*. Hanoi: Hanoi National University (2019).
18. Anh H. *Mobilized More Than 1,000 Last-Year Medical Students to Join the Anti-Epidemic Covid-19*. Thanh Nien Magazine (20/03/2020).

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Impact of the Inflow Population From Outbreak Areas on the COVID-19 Epidemic in Yunnan Province and the Recommended Control Measures: A Preliminary Study

Zhong Sun[1†], Guozhong He[2†], Ninghao Huang[3,4†], Hongyu Chen[2], Shuwei Zhang[2], Zizhao Zhao[2], Yao Zhao[2], Guang Yang[2], Songwang Yang[2], Haiyan Xiong[3,4], Thilakavathy Karuppiah[1,5], S. Suresh Kumar[5,6], Jibo He[7*] and Chenglong Xiong[3,4*]*

[1] Department of Biomedical Science, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, Serdang, Malaysia, [2] School of Public Health, Kunming Medical University, Kunming, China, [3] Department of Epidemiology, School of Public Health, Fudan University, Shanghai, China, [4] Key Laboratory of Public Health Safety, Ministry of Education, School of Public Health, Fudan University, Shanghai, China, [5] Genetics and Regenerative Medicine Research Group, Faculty of Medicine & Health Sciences, Universiti Putra Malaysia, Serdang, Malaysia, [6] Department of Medical Microbiology and Parasitology, Universiti Putra Malaysia, Serdang, Malaysia, [7] Center for Disease Control and Prevention in Yunnan Province, Kunming, China

Background: COVID-19 developed into a global pandemic in 2020 and poses challenges regarding the prevention and control capabilities of countries. A large number of inbound travelers from other regions could lead to a renewed outbreak of COVID-19 in the local regions. Globally, as a result of the imbalance in the control of the epidemic, all countries are facing the risk of a renewed COVID-19 outbreak brought about by travelers from epidemic areas. Therefore, studies on a proper management of the inbound travelers are urgent.

Methods: We collected a total of 4,733,414 inbound travelers and 174 COVID-19 diagnosed patients in Yunnan province from 21 January 2020 to 20 February 2020. Data on place of origin, travel history, age, and gender, as well as whether they had suspected clinical manifestations for inbound travelers in Yunnan were collected. The impact of inbound travelers on the local epidemic was analyzed with a collinear statistical analysis and the effect of the control measures on the epidemic was evaluated with a sophisticated modeling approach.

Results: Of the 174 COVID-19 patients, 60.9% were not from Yunnan, and 76.4% had a history of travel in Hubei. The amount of new daily cases in Yunnan was significant correlated with the number of inbound travelers from Hubei and suspected cases among them. Using Susceptible–Exposed–Infectious–Recovered (SEIR) model analysis, we found that the prevention and control measures dropped the local R0 down to 1.07 in Yunnan province.

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Bach Tran,
Hanoi Medical University, Vietnam

Reviewed by:
Guvenc Kockaya,
ECONiX Research, Analysis and Consultancy Plc., Istanbul, Turkey
Mariela Deliverska,
Medical University-Sofia, Bulgaria

****Correspondence:***
Chenglong Xiong
xiongchenglong@fudan.edu.cn
Guozhong He
guozhong_he@vip.sina.com
Jibo He
ynhejibo@163.com

† These authors have contributed equally to this work

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Conclusions: Our preliminary analysis showed that the proper management of inbound travelers from outbreak areas has a significantly positive effect on the prevention and control of the virus. In the process of resettlement, some effective measures taken by Yunnan province may provide an important reference for preventing the renewed COVID-19 outbreak in other regions.

Keywords: COVID-19, control measures, epidemic area, resettlement, inbound travelers

INTRODUCTION

COVID-19, a novel coronavirus disease that appeared in late 2019, has spread to the majority of countries worldwide, and has resulted in a substantial number of deaths. It was also named SARS-CoV-2 because its symptoms are similar to those of severe acute respiratory syndrome (SARS). COVID-19 was defined as a Public Health Emergency of International Concern by the World Health Organization (WHO) on 30 January 2020 (1). Advances in transportation technology have made life easier and more convenient, and according to data from various destinations, international arrivals (overnight visitors) reached 1.5 billion in 2019 (2). Concurrently, these conveniences have also accelerated the rate of spread of viruses. As international travel increases, travelers are more able to spread infectious diseases acquired in their home countries to their destination, as well as being able to spread diseases from their destination to their home countries. Because of the aforementioned reasons, COVID-19 constituted a major challenge to international public health. According to the prediction model, the basic reproduction number (R0) of COVID-19 is about 2.68 (3). As of 11 March 2020, COVID-19 had already erupted in more than 110 countries, with more than 118,000 confirmed cases, and 4,291 people having lost their lives. On the same day, the World Health Organization (WHO) declared the COVID-19 outbreak a global pandemic (4).

Since the outbreak of COVID-19, in response to the spread of such viruses through travel, many countries have implemented large-scale blockades to slow the spread. For example, an unprecedented lockdown was imposed by the Chinese government in Wuhan from 23 January 2020, with travel restrictions. Within a few days, the quarantine expanded to other provinces and cities, affecting more than 50 million people in total (5). Unfortunately, more than 5 million people left Wuhan before lockdown due to the upcoming Spring Festival, many of whom may have been infected with the virus (6). Thus, these travelers who left the affected area before the blockade were able to spread COVID-19 to other parts of China and around the world. Although countries have adopted active countermeasures to prevent both imported and exported cases, most countries in the world will be faced with undetected travelers from affected areas moving to non-affected areas.

Yunnan province, a very popular tourist destination, ranking third in China, received a total of 7.0608 million domestic and foreign overnight tourists in 2018 (7). Most provinces in China refused to accept tourists from Hubei during the epidemic. However, Yunnan province became a gathering place for travelers from Hubei, since it allowed entry to Hubei tourists. In this preliminary study, we therefore selected Yunnan Province as an example to discuss the management of travelers from affected areas after an outbreak. To evaluate the effectiveness of the measures taken in Yunnan, we collected and analyzed the monitoring data of inbound travelers and the isolation data of hotels during the outbreak in Yunnan Province. The results of this study may provide some reference and guidance on how to regulate outbound travelers from affected areas in the future.

MATERIALS AND METHODS

Epidemiological Data

We survey all 174 patients diagnosed as COVID-19 in Yunnan province. The first COVID-19 patient in Yunnan Province was diagnosed on 21 January 2020, and the 174th patient was diagnosed on 20 February 2020, with no new cases within the next 2 weeks. All the data were collected from the Epidemic Command Center, which is composed of the People's Government of Yunnan Province, the Health Commission of Yunnan Province, the Yunnan Center for Disease Control and Prevention, the Yunnan Provincial Department of Culture and Tourism, and the Department of transport of Yunnan Province. The province-wide control of Yunnan province began on 28 January 2020. The data include surveys of the inbound travelers in eight Prefectural-level municipalities and eight Autonomous prefectures in Yunnan province from 28 January to 20 February 2020. The content of the investigation includes daily visitors to Yunnan, who were asked their domicile of origin and whether they had suspicious clinical manifestations (such as an abnormal body temperature, cough, shortness of breath, etc.). In addition, it also includes the number of new daily cases, deaths, and recovered cases during this period. We also extracted data on gender, age, place of origin, and history of travel in Hubei of all 174 patients during this period. The data used are officially released, all patients are anonymous, and do not involve any personal privacy, therefore, no ethical approval is required from author corporate for the people and animals.

Data Analysis

All data were proofread and double entered using EpiData3.1 software to ensure accuracy. Data were transformed into the database through Excel 2019 software, and statistically analyzed using SPSS version 25.0. Based on patients' place of origin, we categorized the patients into three groups (e.g., Hubei, Yunnan, other provinces). To analyze the differences on gender, age, and history of travel in Hubei among these three different groups, a descriptive statistical analysis was conducted and Chi-squire tests

TABLE 1 | Descriptive statistical characteristics of 174 COVID-19 patients (place of origin, history of travel in Hubei, gender, and age).

Characteristics	Place of Origin			Chi-square	*P*-value
	Hubei ($n = 85$)	Yunnan ($n = 68$)	Other provinces ($n = 21$)		
History of Travel in Hubei				51.836	0.000
Yes	85 (100.00)	38 (55.88)	10 (47.62)		
No	0	30 (44.12)	11 (52.38)		
Sex				0.203	0.904
Male	42 (49.41)	36 (52.94)	11 (52.38)		
Female	43 (50.59)	32 (47.06)	10 (47.62)		
Age Distribution				9.485	0.050
<18 years	9 (10.59)	9 (13.24)	1 (4.76)		
18–65 years	60 (70.59)	54 (79.41)	20 (95.24)		
>65 years	16 (18.82)	5 (7.35)	0		

were performed for these 174 diagnosed patients. In addition, multiple linear regression analysis was used to screen for variables using stepwise methods. A final model was constructed with the independent variable of the number of new cases per day in Yunnan Province, and the dependent variables of the amount of daily inbound travelers (from Hubei Province) and the amount of suspected infected persons among them. A p-value of <0.05 (typically <0.05) was considered statistically significant.

Furthermore, we parameterized the above data (also including the daily deaths and recoveries in Yunnan) based on the Susceptible–Exposed–Infectious–Recovered (SEIR) model (8) and estimated the R0 (basic reproduction number of the disease transmission) under the control interventions of Yunnan with Matlab software (MATrix LABoratory) (9).

RESULTS

Basic Characteristics of COVID-19 Cases in Yunnan Province

From the first suspected case being confirmed as a pneumonia case caused by SARS-CoV-2 on 16 January 2020, Yunnan Province accumulated 174 confirmed cases as of 24 February. **Table 1** and **Figure 1** show the results of the descriptive statistical analysis of 174 patients.

Among the 174 confirmed COVID-19 cases, there were 85 cases originally from Hubei province (48.9%), 68 cases originally from Yunnan province (39.1%) and 21 cases originally from other provinces (12.1%), indicating that majority of the patients (70.9%) did not originally come from Yunnan. Regarding the travel-history in Hubei, A total of 133 cases (76.4%) had a history travel in Hubei province. The number of male patients was slightly higher than that of female patients [89 males (51.1%) and 85 females (48.9%)]. In addition, patients were mainly distributed in the 18–65 years group (132 cases, 75.9%). The youngest patient was 3 years old, and the oldest patient was 83 years old. The average age of the patients was 41 years. Among 174 COVID-19 patients in Yunnan province, only two patients died, and both of whom were males older than 65 years. The other 172 patients were recovered by the end of this study.

Analysis of the Correlation Between the Daily Number of New Cases and the Inbound Population

Table 2 shows the daily arrivals in Yunnan province and suspected infected persons among them from 28 January 2020 to 20 February 2020, and the daily arrivals in Yunnan province from Hubei and the suspected infected persons among them. **Table 2** also lists the new daily cases of COVID-19 in Yunnan Province during this period. The amount of daily inbound travelers and the number of suspected infected persons among them are listed separately. In addition, we provided the information on the amount of daily inbound travelers from Hubei and the number of suspected infected persons among them separately.

With the multiple linear regression analysis, we found that the number of inbound travelers and suspected cases among them are not significantly correlated with the number of new daily cases, and the p-values are 0.730 and 0.879, respectively. However, the number of inbound travelers from Hubei and suspected cases among them are significantly correlated with the number of new daily cases with the p-values of 0.018 and 0.024, respectively.

The stepwise method was used to eliminate the two independent variables: the number of inbound travelers and suspected cases among them. A linear regression model can be obtained with R square = 0.634, F = 18.203, and a p-value of <0.05. The model is as follows: the number of new cases per day = 11.42 – 0.000655* the number of inbound travelers from Hubei + 0.03886* suspected cases from the inbound travelers from Hubei. Meanwhile, we combined the three variables in the model with time. The time series plot is shown in **Figure 2**.

Epidemic Model

Based on the daily number of new cases, recovered cases, and deaths in Yunnan, we constructed the SEIR model (**Figure 3**) to describe the status of each compartment shown in the following differential equations:

$$N = S + E + I + R$$
$$\frac{dS}{dt} = -\beta I\frac{S}{N}$$
$$\frac{dE}{dt} = \beta I\frac{S}{N} - \frac{1}{T_i}E - \alpha E$$
$$\frac{dI}{dt} = \frac{1}{T_i}E - \frac{1}{T_r}I$$
$$\frac{dR}{dt} = \frac{1}{T_r}I + \alpha E$$

We stratified the populations into susceptible (S), exposed (E), infected (I), and recovered or removed (R). Furthermore, N is the total number of people, β is disease transmission rate, α is the

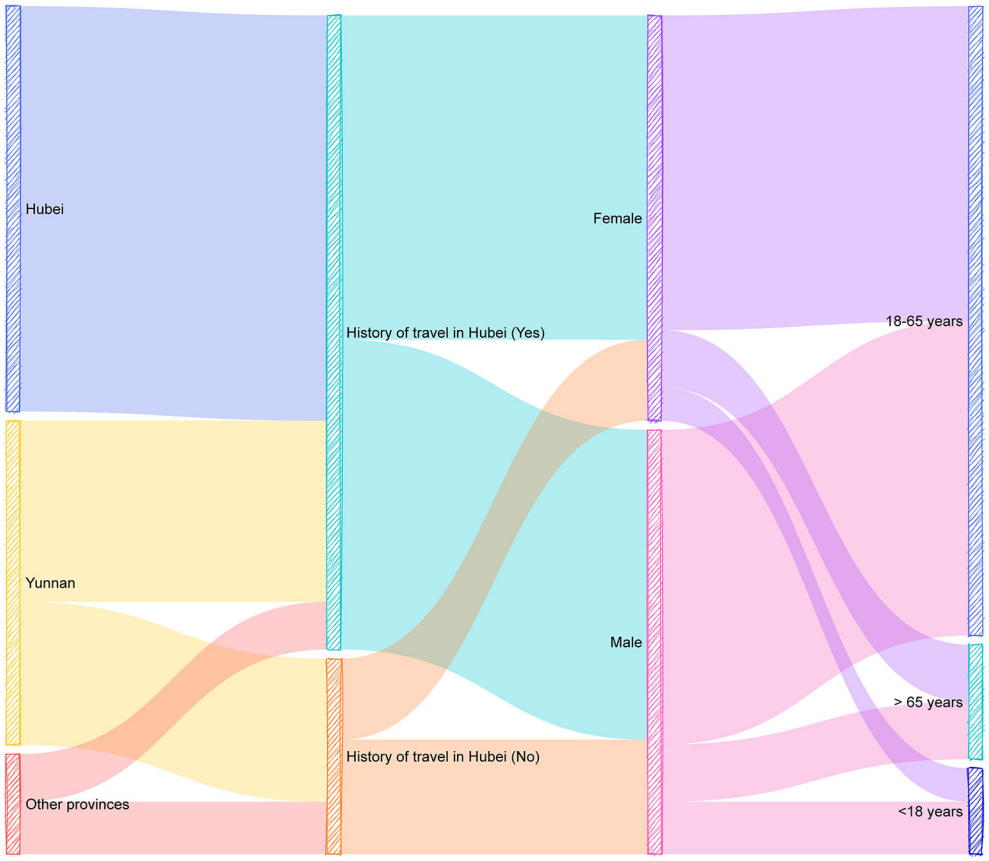

FIGURE 1 | Illustration of descriptive statistical characteristics of 174 COVID-19 patients.

rate of (I) direct conversion to (R). T_i is days of (E) converted to (I), and T_r is days of (I) converted to (R).

We fitted the data according to the above model. Through data simulation, the number of infected people was calculated by the fitting prediction. Among them, the loss function is the mean variance of the actual number of infected people minus the predicted number of infected people. The minimum value of the loss function was found by using the gradient descent method. With the Matlab software (MATrix LABoratory), we concluded that

$$R0 = \left(T_I{}^2 \times T_r{}^2 \times \alpha^2 - 2 \times T_i{}^2 \times T_r \times \alpha + T_i{}^2 + 2 \times T_i \times T_r{}^2 \times \alpha + 4 \times \beta \times T_i \times T_r{}^2 - 2 \times T_i \times T_r + T_r{}^2\right)^{\frac{1}{2}} \cdot \div \left(T_i \times T_r \times \alpha + T_i + T_r\right)$$

For this model, there is no endemic equilibrium as the S, E, I, R in the model will all return to zero once the epidemic has finished. We linearized our system around each equilibrium using the Jacobian matrix evaluated at the chosen equilibrium. Otherwise, the local equilibrium was unstable (10). Based on this equilibrium, we obtained the values of this area: $\beta = 11.12$, $\alpha = 5.11$, $T_i = 8.64$, $T_r = 18.84$, $R0 = 1.07$ (**Figure 4**).

DISCUSSION

Although Hubei province implemented a strict city closure order, there were still many people from Hubei moving outside, which is what we mean by inbound travelers from affected areas. Meanwhile, Yunnan Province became the first province in China to release information about designated hotels during the outbreak. As of 17 February 2020, the number of designated resettlement hotels increased to 187, and the cumulative number of tourists resettled in Yunnan reached 42,493, including 5,816 tourists from Hubei and 2,552 from Wuhan (11). However, it is worth noting that under the strict prevention and control measures implemented in Yunnan, COVID-19 did not break out locally, and our study suggested that the local R0 dropped to 1.07 in Yunnan Province is worthy of reference and discussion.

SARS-COV-2 (R0 = 2.68) seems to be more contagious than SARS-CoV (R0 = 2.2) and MERS-CoV (R0 = 1.21) (3, 12, 13). The statistics from 174 patients with COVID-19 contained 89 males, accounting for about 51.1%, slightly more than females. Majority of patients were in the 18–65 age group, accounting for ∼75.9%, and the median age was 40 years. Furthermore, only two COVID-19 patients died in Yunnan province, both of whom were males older than 65 years. The incidence of male morbidity is higher than that of females, which has also been confirmed

TABLE 2 | List of daily inbound travelers and new daily cases, recovered, and deaths in Yunnan from 28 January 2020 to 20 February 2020.

Date	Inbound Travelers from Hubei		Inbound Travelers		New Daily Cases	New Daily Recovered	New Daily Deaths
	Total	Suspected Cases	Total	Suspected Cases			
1.28	17,857	438	143,469	860	25	0	0
1.29	23,141	480	238,092	722	19	0	0
1.30	27,598	598	233,520	1,209	10	0	0
1.31	29,201	570	254,982	1,176	11	1	0
2.1	39,884	568	212,555	1,501	8	1	0
2.2	36,634	522	316,851	1,067	10	1	0
2.3	38,641	524	257,567	808	8	2	0
2.4	35,688	460	258,137	619	5	0	0
2.5	35,530	457	266,758	691	6	0	0
2.6	36,936	462	267,514	753	7	2	0
2.7	36,324	444	272,907	941	3	5	0
2.8	35,495	459	278,214	733	2	5	0
2.9	36,410	435	284,578	813	1	1	0
2.10	34,813	437	306,706	790	8	1	0
2.11	29,450	192	162,175	597	5	1	0
2.12	26,130	159	139,795	523	1	3	0
2.13	20,037	95	106,101	445	7	4	0
2.14	19,713	96	116,493	338	6	8	0
2.15	18,900	90	105,613	349	1	7	0
2.16	17,523	88	102,758	304	2	0	0
2.17	17,017	114	102,592	258	1	5	0
2.18	16,786	85	102,036	220	1	10	0
2.19	16,495	74	101,310	209	0	3	1
2.20	15,370	61	102,691	191	1	19	1
Total	661,573	7908	4,733,414	16,117	148	79	2

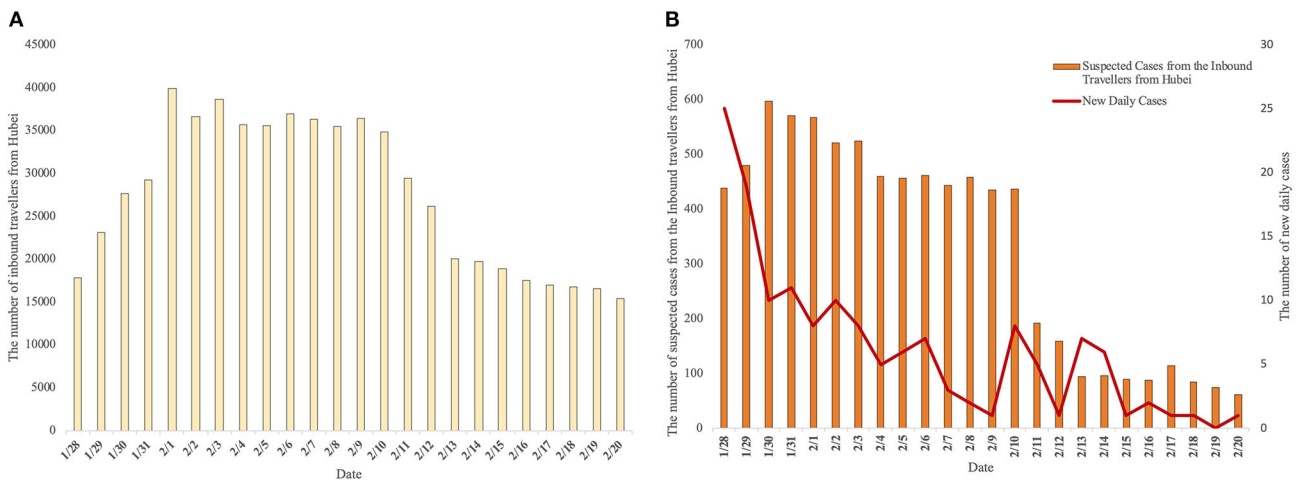

FIGURE 2 | Time series chart of variables related to new daily cases in Yunnan Province. **(A)** Shows the number of daily inbound travelers from Hubei. **(B)** Shows the number of suspected cases from inbound travelers from Hubei and new daily cases.

in two other studies (14, 15). This may be related to females having a higher innate and adaptive immune response than men, leading to faster elimination of the virus (16). However, the corresponding pathogenic and molecular biological foundations for this still need to be explored further.

In the place-of-origin statistics from the 174 patients, we found that non-Yunnan patients accounted for 60.9%. Meanwhile, in the history-of-travel statistical results of all the patients, people from or who had been through Hubei accounted for 76.4% of the total number. All of the above indicates that

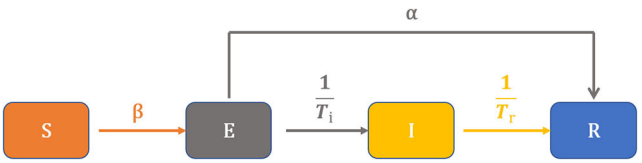

FIGURE 3 | Diagram of the model used in this study for simulating the COVID-19 infection.

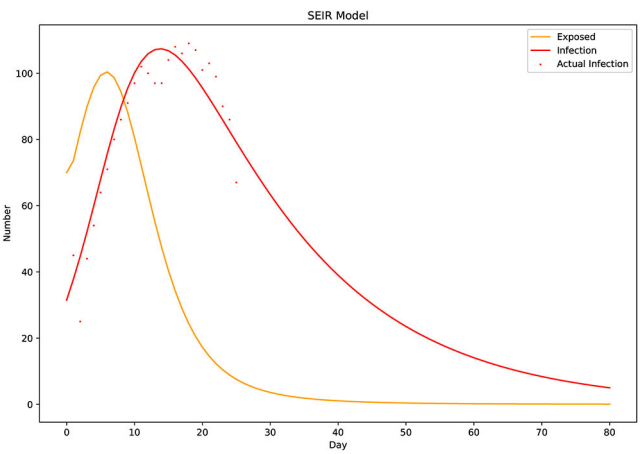

FIGURE 4 | The Susceptible–Exposed–Infectious–Recovered (SEIR) model. A simulation graph drawn according to the model and the number of known daily infections, deaths, and recoveries. According to the model, epidemics occur because R0 > 1, although the fit is not optimal at the beginning of the epidemic. The calculations indicate that unsureness is related to the initial number of exposed individuals. The incubation period T_i is 8.6 days, which can be reflected in the SEIR model (**Figure 4**). The infection curve (red) is one incubation period later than the exposure curve (yellow), and the gap continues to widen in the later stages. Because the rate of progression from exposure to infectious ($1/T_i$) was greater than the recovery rate of infectious individuals ($1/T_r$), the number of infected people declined faster than the number of exposed people.

the diagnosed patients in Yunnan Province were closely related to the outflow population from Hubei Province. During the outbreak of COVID-19 in China, we became aware of the potential insecurity factor. As a result of the large-scale blockades and control activities in China, a lot of outbound travelers from epidemic areas became homeless. Meanwhile, they were often unable to enter Hubei directly and were quarantined in other cities for 2 weeks, after which most of them were required to return to their places of origin. However, as a result of the epidemic in Hubei and the closure of the city, some outbound travelers from Hubei did not want to return to the epidemic areas. Because of their specific situation, people in most cities did not want to accept them. Even when a small number of outbound travelers intended to return to the affected areas, they were refused admittance to public/private transport facilities due to their identity and destination. As a result of the above factors, there was a phenomenon in which outbound tourists could not return home and thus became homeless.

In our statistical study, the above phenomenon has been confirmed. Even though the authorities adopted a strict city closure directive, there were still numerous people from the epidemic areas entering Yunnan province every day. Meanwhile, our correlation analysis also confirmed that the new daily cases of COVID-19 in Yunnan had a significant correlation with the number of inbound travelers from Hubei and the suspected cases among them. This shows that during the outbreak, the outflow of people from affected areas is not only the main reason for the persistence and spread of the epidemic, but also the main source of imported cases overall.

In this study, according to the model we established, the management and control of outbound travelers from epidemic areas can effectively and rapidly control the spread of the epidemic. Therefore, this study also focuses on investigating the measures taken to quickly control the current epidemic in Yunnan Province. We believe that the following prevention and control measures implemented in Yunnan are worthy of reference and promotion.

First, in the prevention and control of the epidemic, all inbound travelers should be screened and checked, with special attention being paid to those who have traveled from affected areas. In China, the Department of Telecommunications provides mobile phone users with free travel history inquiry services, which can be provided to the relevant infection prevention and control department to facilitate the registration and verification of whether the user has been to an epidemic area (17). As human beings enter the information age, although the speed of virus transmission is much faster than before, big data can assist human beings in the prevention and control of infectious diseases to a certain extent (18).

Second, the lower floors of designated hotels should be used for those who need be separated. As early as 2003, when the SARS virus broke out in Hong Kong, researchers found that people on the lower floors were infected by the virus by people on the upper floors who were infected and also had symptoms of diarrhea. The virus can spread as an aerosol through a sewer pipe to the bathroom system downstairs through feces. This way, resident's downstairs can become infected by coming into contact with small droplets containing the virus (19). In a study of SARS-CoV-2, although the patient had no symptoms of diarrhea, samples from the toilet and sink in their room were positive, indicating that virus shedding in feces may be a potential route of transmission (20). Therefore, arranging people who need attention on the lower floors is helpful to reduce the potential aerosol infection caused by the drainage system.

Third, positive and effective countermeasures should be taken to deal with the extensive environmental pollution that may be caused by tenants. Although COVID-19 patients cause extensive environmental pollution, a study showed that the air samples were negative since the air in isolation chambers is exchanged 12 times per hour, though the swab test of the exhaust port was positive (20). The data suggested that increased air circulation is conducive to virus dilution. It also proves that the air loaded with virus aerosol is discharged through the exhaust device, with some small water droplets carrying virus being deposited on the vent and other devices during the air discharge process (20).

Therefore, it is necessary to maintain indoor air circulation. Each floor and each room need to improve ventilation by opening windows (usually for more than 3 h). At the same time, exhaust devices such as exhaust fans can be turned on to enhance indoor air flow. In places where centralized air-conditioning is used, the return air must be closed and the air conditioning filter must be cleaned regularly. A survival study on SARS-CoV-2 showed that it can survive on metal, glass, and plastic surfaces for anywhere from 2 h to 9 days (21). It has also been reported that alcohol-containing disinfectants can effectively kill the viruses attached to the surface of objects (21). Therefore, the indoor floors, walls, public supplies of guest rooms should be disinfected once a day. Moreover, elevator buttons, doorknobs, and other frequently touched parts should be disinfected at least three times a day.

While in various countries where the epidemic has been brought under control, there is still a potential risk of recurrent outbreaks due to travel between affected and non-affected areas (22). As early as 2016, a sample survey of nasal and pharyngeal swabs of foreign tourists without respiratory symptoms in New York City found that 6.2% of travelers tested positive for respiratory viruses, of which 38.7% carried coronavirus (23). In a survey on SARS-CoV-2, it was found that the results of nasal and pharyngeal swab tests in asymptomatic or mild-symptom patients showed similar virus levels to those of symptomatic patients, indicating that asymptomatic patients were also capable of transmission (24). Therefore, when a person is in close contact with someone who has no respiratory symptoms (within 1 m), their mucous membranes (mouth and nose) or conjunctiva (eyes) are also at risk of being infiltrated by droplets. Therefore, it is necessary to wear a mask when contacting people from affected areas (25).

CONCLUSION

With the unsynchronized development of COVID-19, countries and regions will face various forms of imported cases. How to manage these imported cases is the top priority. Because it was a province that accepted people from affected areas during the outbreak of the epidemic in China for a long period of time, Yunnan province applied some temporary and effective public health interventions to prevent the virus from breaking out in the region. Although only a small number of cases included in this preliminary study, the results demonstrated that positive screening of inbound travelers and proper resettlement of travelers from epidemic areas have a very positive effect on the prevention and control of the outbreak. In the process of accommodating people from infected areas, we believe that they should be placed on the lower floors, and all hotel personnel should wear masks before coming into contact with them. Meanwhile, maintaining hand hygiene, a safe social distance, and using alcohol-based disinfectants can effectively reduce the spread of the virus. These effective prevention and control measures may provide some reference for preventing the renewed COVID-19 outbreak in other regions.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary materials, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

ZS designed, drafted, and edited the manuscript. JH provided data and edited the manuscript. NH edited the figures. HC, SZ, ZZ, YZ, GY, and SY collected data. HX and SK edited the manuscript. TK reviewed and edited the manuscript. GH and CX conceptualized and designed framework of manuscript. All authors have made contribution to this manuscript and have read and agreed to the published version of the manuscript.

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REFERENCES

1. Statement on the second meeting of the International Health Regulations. *Emergency Committee Regarding the Outbreak of Novel Coronavirus (2019-nCoV)*. (2005). Available at: https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov) (accessed September, 24, 2020).
2. UNWTO world tourism barometer and statistical annex, January 2020. *UNWTO World Tour* Barom. (2020) 18:1–48. doi: 10.18111/wtobarometereng.2020.18.1.1
3. Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. *Lancet*. (2020) 395:689–97. doi: 10.1016/S0140-6736(20)30260-9
4. *COVID-19 Public Health Emergency of International Concern (PHEIC) Global Research and Innovation Forum*. Available online at: https://www.who.int/publications/m/item/covid-19-public-health-emergency-of-international-concern-(pheic)-global-research-and-innovation-forum (accessed September 24, 2020).
5. Wang C, Pan R, Wan X, Tan Y, Xu L, Ho CS, et al. Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. *Int J Environ Res Public Health*. (2020) 17:1729. doi: 10.3390/ijerph17051729
6. *5 Million-Plus Leave Wuhan: Mayor*. Chinadaily.com.cn Available online at: https://www.chinadaily.com.cn/a/202001/27/WS5e2dcd01a310128217273551.html (accessed September 24, 2020).
7. China Statistical Yearbook 2019. *China YearBooks*. Available online at: https://www.chinayearbooks.com/china-statistical-yearbook-2019.html (accessed September 24, 2020).
8. Hou C, Chen J, Zhou Y, Hua L, Yuan J, He S, et al. The effectiveness of quarantine of Wuhan city against the Corona Virus Disease 2019 (COVID-19): a well-mixed SEIR model analysis. *J Med Virol*. (2020) 92:841–8. doi: 10.1002/jmv.25827

9. Siriprapaiwan S, Moore EJ, Koonprasert S. Generalized reproduction numbers, sensitivity analysis and critical immunity levels of an SEQIJR disease model with immunization and varying total population size. *Math Comput Simul.* (2018) 146:70–89. doi: 10.1016/j.matcom.2017.10.006
10. Blackwood JC, Childs LM. An introduction to compartmental modeling for the budding infectious disease modeler. *Lett Biomath.* (2018) 5:195–221. doi: 10.30707/LiB5.1Blackwood
11. *A Total of 42,493 Inbound Tourists Were Resettled in Yunnan, Including 5,816 Tourists From Hubei*. Yunnan Online Press Hall (n.d.). Available online at: http://www.yn.gov.cn/ynxwfbt/html/2020/zuixinbaodao_0218/2381.html (accessed September 24, 2020).
12. Lipsitch M, Cohen T, Cooper B, Robins JM, Ma S, James L, et al. Transmission dynamics and control of severe acute respiratory syndrome. *Science (80-.).* (2003) 300:1966–70. doi: 10.1126/science.1086616
13. Cauchemez S, Fraser C, Van Kerkhove MD, Donnelly CA, Riley S, Rambaut A, et al. Middle East respiratory syndrome coronavirus: quantification of the extent of the epidemic, surveillance biases, and transmissibility. *Lancet Infect Dis.* (2014) 14:50–6. doi: 10.1016/S1473-3099(13)70304-9
14. Chen T, Wu D, Chen H, Yan W, Yang D, Chen G, et al. Clinical characteristics of 113 deceased patients with coronavirus disease 2019: retrospective study. *BMJ.* (2020) 368:m1091. doi: 10.1136/bmj.m1091
15. Guan W, Ni Z, Hu Y, Liang W, Ou C, He J, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med.* (2020) 382:1708–20. doi: 10.1056/NEJMoa2002032
16. Klein SL, Flanagan KL. Sex differences in immune responses. *Nat Rev Immunol.* (2016) 16:626–38. doi: 10.1038/nri.2016.90
17. *Ministry of Industry and Information Technology: Provide Mobile Phone Users With Free Inquiries to Visit Places*. The Paper (n.d.). Available online at: https://www.thepaper.cn/newsDetail_forward_6317466 (accessed September 24, 2020).
18. Qiu H-J, Yuan L-X, Wu Q-W, Zhou Y-Q, Zheng R, Huang X-K, et al. Using the internet search data to investigate symptom characteristics of COVID-19: a big data study. *World J Otorhinolaryngol Head Neck Surg.* (2020). doi: 10.1016/j.wjorl.2020.05.003. [Epub ahead of print].
19. Hung LS. The SARS epidemic in Hong Kong: what lessons have we learned? *J R Soc Med.* (2003) 96:374–8. doi: 10.1177/014107680309600803
20. Ong SWX, Tan YK, Chia PY, Lee TH, Ng OT, Wong MSY, et al. Air, surface environmental, and personal protective equipment contamination by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) from a symptomatic patient. *JAMA J Am Med Assoc.* (2020) 323:1610–2. doi: 10.1001/jama.2020.3227
21. Kampf G, Todt D, Pfaender S, Steinmann E. Persistence of coronaviruses on inanimate surfaces and their inactivation with biocidal agents. *J Hosp Infect.* (2020) 104:246–51. doi: 10.1016/j.jhin.2020.01.022
22. Chinazzi M, Davis JT, Ajelli M, Gioannini C, Litvinova M, Merler S, et al. The effect of travel restrictions on the spread of the 2019 novel coronavirus (COVID-19) outbreak. *Science (80-).* (2020) 368:395–400. doi: 10.1126/science.aba9757
23. Birger R, Morita H, Comito D, Filip I, Galanti M, Lane B, et al. Asymptomatic shedding of respiratory virus among an ambulatory population across seasons. *mSphere.* (2018) 3:249–67. doi: 10.1128/mSphere.00249-18
24. Zou L, Ruan F, Huang M, Liang L, Huang H, Hong Z, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N Engl J Med.* (2020) 382:1177–9. doi: 10.1056/NEJMc2001737
25. Prather KA, Wang CC, Schooley RT. Reducing transmission of SARS-CoV-2. *Science (80-).* (2020) 368:1422–4. doi: 10.1126/science.abc6197

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OPINION
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COVID-19 Employment Crisis in Vietnam: Global Issue, National Solutions

Huong T. T. Nguyen[1], Tham T. Nguyen[1], Vu A. T. Dam[1], Long H. Nguyen[2], Giang T. Vu[3], Huong L. T. Nguyen[4,5], Hien T. Nguyen[4,5] and Huong T. Le[1]*

[1] School of Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] Vietnam National University School of Medicine and Pharmacy, Vietnam National University, Hanoi, Vietnam, [3] Center of Excellence in Evidence-Based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam, [4] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [5] Faculty of Nursing, Duy Tan University, Da Nang, Vietnam

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Since the first case being reported in January 23, Vietnam has 911 confirmed cases (430 recovered and 460 actives) with 21 fatalities (1). A large number of people being infected and died from the disease, unprecedented measures taken by Vietnam government to curb the infection rate—from social distancing to locking down which involve business closing, have significantly affected economy, especially in terms of employment. Specifically, the groups of industries such as: Aviation services; Hotel/Food and Beverage Service and other services when revenue dramatically decreased about 50 and 23.6%, respectively, compared to the same period last year (2). According to the General Statistics Office of Vietnam, in the first 6 months of 2020, the number of enterprises suspending business for a definite time was 29.2 thousand, increasing by 38.2% over the same period last year, while 19.6 thousand enterprises stopped and focused mainly on the service sector. There were 897.5 thousand people losing jobs while the number of unemployed people was at 1.3 million, an increase of 123.9 thousand, making the unemployment rate reaching the highest point in 10 years (3). In which, the groups of non-working age groups, female workers, unskilled workers, migrant workers, and informal workers are the most vulnerable groups caused by pandemic (4, 5). In particularly, the female workers group, the unemployment rate was about 2.9%, higher than that of men and increased sharply over the same period last year (3) and for the informal workers—workers without labor contracts, unemployment insurance (4), there was 72% of those in the group affected by the COVID-19 pandemic when they mainly focused on Industry groups suffered the most damage: F&B, Hotel, logistic, etc. (6–8). In addition, domestic migrant workers, which account for 13.6% of the total population, often work in the informal economy without a work contract and without access to social protection regimes (8).

However, one thing is clear. With various forms of lockdowns and social distancing, Vietnam are facing a really difficult time. Out of 51.8 million employed workers in the second quarter of this year, 30.8 million people were affected by epidemics, of which 2.4 million workers lost their jobs, the national unemployment rate increase (7). In which, about 17.6 million people suffer income loss due to disease, accounting for 57.3% of the total affected people (9). COVID-19 pandemic directly impact employment. The number of employees in several occupations decreased a sharp fall compared to the last year as follows: unskilled group reduced by nearly 1.5 million workers, equivalent to nearly 8%; the group of craft and related trades workers decreased by 515 thousand persons, equivalent to a fall of 6.6%; the number of employees in the middle-level qualification group fell by 322 thousand persons, equivalent to a decrease of 16.5% (6). The General statistics office of Vietnam reported that the average monthly income of workers decreased for the first in 5 years. Especially, the deepest decrease in monthly average income in the 2nd quarter of 2020 compared to the same period last year as follows "Arts, entertainment and recreation,"

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Wonkwang University, South Korea

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***Correspondence:**
Huong L. T. Nguyen
nguyentlanhuong5@duytan.edu.vn

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"accommodation and catering service." "transportation and storage" "wholesale and retail trade and repair of motor vehicles and motorcycles" down 19.2, 18.3, 12.8, and 9.1%, respectively (6). With unemployment rising and income per labor reduction has led to the economic growth rate only reached the level of 1.81% in the first 6 months of the year—the lowest figure recorded in the whole period 2011–2020 (10). The COVID-19 pandemic caused the income of many Vietnamese households to decrease by 70% (11). In addition, household income deepest decrease the most due to the Covid-19 epidemic, recorded in April 2020, when only 29.7% compared to December 2019. This figure to May 2020 is 51.1% (11). Children can also be affected by loss of a job or income loss from their parents (8). More than 21 million students in Viet Nam being affected by school closures (12). It is estimated that more than 1 million childrens aged 5–17 years are engaged in child labor, this children were face to work longer hours or in worse conditions (13). During the COVID-19 pandemic, dropouts, malnutrition, labor exploitation, and child labor can increase dramatically. This lead to serious consequences, especially for the development of the workforce.

With the negative impact of COVID-19 pandemic, Vietnam's economic growth in 2020 also was decreased by about 4% compared to last year (14, 15). However, the Vietnam government had several solutions manage the fiscal deficit for solving immediate problems such as focus on effectively implementing domestic stimulus, use the savings from falling international oil prices to curb the crisis, earn funding from the World Bank WB and the International Monetary Fund, etc. (16, 17). Besides, economic recovery solutions such as promoting production, business, socio-economic development are also offered in three main contents: General solutions; urgent solutions; and Long-term solutions (**Figure 1**). Firstly, according to The Politburo on the policy of overcoming the impact of the COVID-19 pandemic to improve and develop the economy, the Government would provide support in the form of (1) to make the most of the domestic market, at the same time to prevent and respond to instabilities from outside; (2) to develop a favorable and attractive business environment, suitable to new trends, and have regional and international competitiveness; (3) to identify opportunities and challenges to take advantage of solutions, transform opportunities, and challenges into motivation on economic growth (18). Secondly, for urgent solutions for solving immediate problems consist of (1) extension for payment of tax and other duties (social insurance, trade union fees, etc.); (2) financial assistance through policies that require lending institutions to reduce lending rate, facilitate debt rescheduling, provide liquidity for businesses affected by COVID-19; (3) monetary allowance and 0% interest loan for those having their employment affected by the pandemic; and (4) promoting of

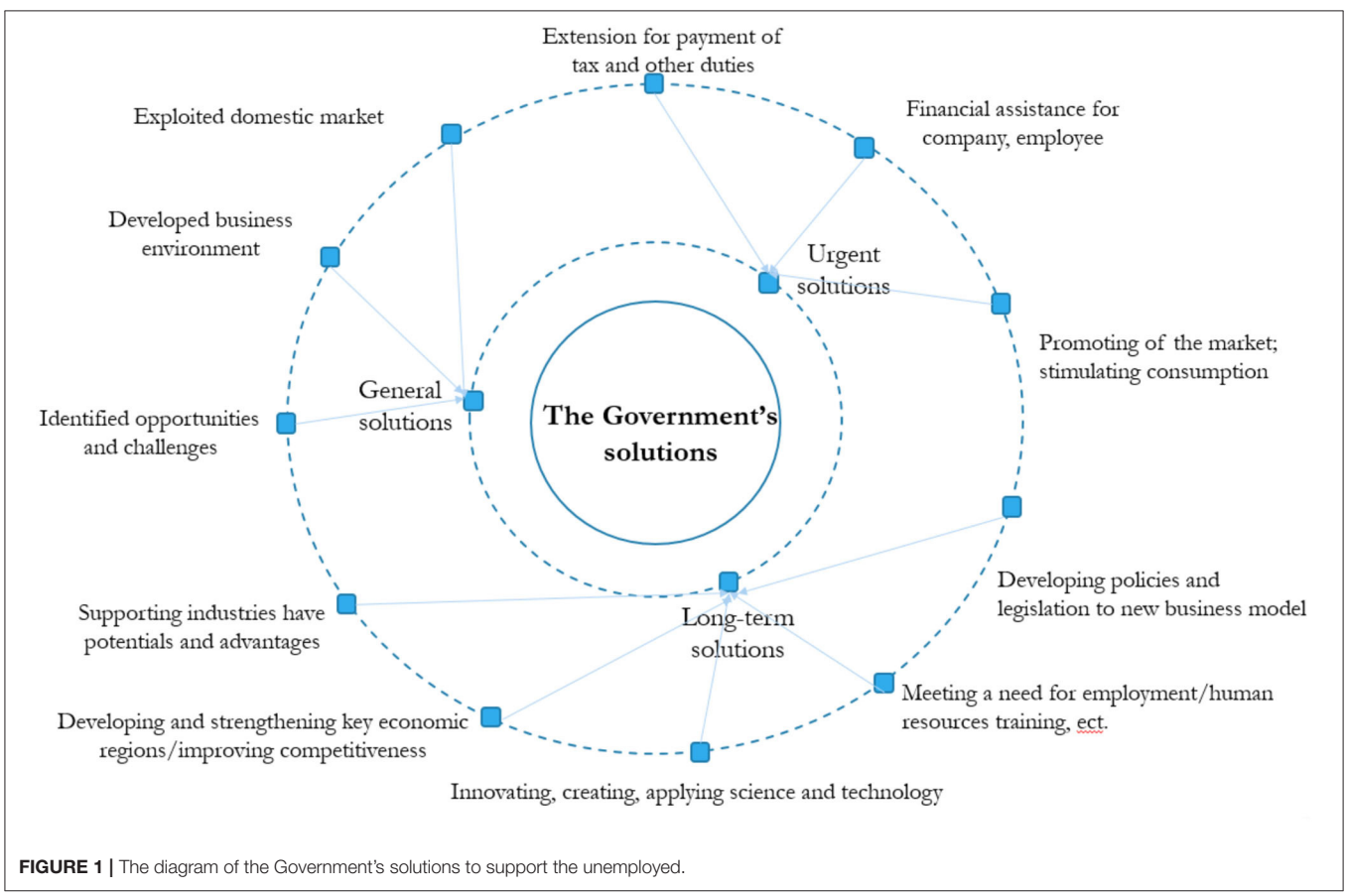

FIGURE 1 | The diagram of the Government's solutions to support the unemployed.

the domestic market and stimulating domestic consumption (19–21). In addition, some solutions such as Stop paying social insurance, stop paying premiums, reduce union fee by 50% and reduce 15% land rent reduction policy should be applied to all businesses because most of the businesses are affected, possibly operating but facing many difficulties (according to Resolution 84). Stabilize electricity and water prices of enterprises and eliminate monopoly prices in this field. A number of policies on banking and finance such as solutions to support liquidity, debt rescheduling, and debt group retention; Reduce lending interest rates; Extending credit guarantee measures so that small, medium and micro-enterprises, business households can borrow capital (22). Specifically, the Vietnamese government has introduced a US $ 2.7 billion relief fund to support all workers affected by the COVID-19 pandemic in Vietnam. In particular, this bailout package focus on support for businesses in difficulty, workers deeply affected by income, and vulnerable people who are not supported to access many existing social security networks within 3 months (April, May, and June) with different levels of support for each group of workers (23). Finally, for long-term solution, Vietnam's government have strategies include (1) developing policies and legislation to facilitate new business models; (2) economic restructuring and support potential and advantageous industries; (3) improving competitiveness and support businesses/enterprise; (4) innovating, creating, applying science and technology; (5) meeting a need of social security, employment, and human resources training; and (6) developing and strengthening key economic regions. Vietnam has drastically rectified the job crisis related to COVID-19 and most importantly, minimizes the damage that affects businesses and employees. Therefore, it is important to ensured that the socio-economic policy is built based on three aspects: the Government, employers, and workers. Vietnam has dealt with the job crisis related to COVID-19 drastically. It is important to minimize damage affecting businesses and workers. This is an important time to ensure that the socio-economic policy is built in an inclusive manner based on government, employers, and workers. These difficult times provide an opportunity for Vietnam to establish a more inclusive growth platform.

In COVID-19 pandemic, Vietnam faces many opportunities and challenges for the businesses as well as workers in the process of adapting to the new economic model. Generally, the business market suffered heavy losses due to the crisis, which led to an inordinate increase in the unemployment rate (2.73%) (7). In terms of urgent period, there are several challenges for the economy when market demand decreased and becomes more competitive due to some industries are strongly affected such as the GDP of export industry and services decreased about 8.45–9.67% (7). This also leads to the highest unemployment rate in the 10 years and a concentration of a large number of vulnerable labor (6). Therefore, business owners need to grasp the demand for their products/services as well as the availability of labor force during and after the pandemic, to identify new opportunities and implement timely business model transformation. Additionally, it requires the Government and business to offer several measures to support workers especially the vulnerable group: financial support and job hunting (23, 24). Besides the challenges, some policies have been introduced to support businesses to maintain business, retain employees, and minimize employee layoffs (25). Specifically, businesses are entitled to tax extension, tax reduction, and financial support (22). Therefore, the risk of unemployment and income reductions can be reduced, especially in sectors such as services and import-export which are most affected (26). In the long term, businesses can be affected for a long time and the business market in Vietnam needs time to recover. Key sectors such as service and import-export still suffer due to the disease's complicated evolution of the epidemic and the mandatory quarantine policy upon entry in Vietnam (According to Official dispatch 1440 of the National steering committee for Disease Control and Prevention COVID-19). Vietnam implemented a social division from April 1 to April 23 (According to Directive 15 of the National steering committee for Disease Control and Prevention COVID-19). This lead to several opportunities and challenges for companies and employees. Specifically, businesses need to develop existing markets and exploit new markets such as developing the domestic market when import-export is limited, and prioritize the development of the online transaction market. From there, it is possible to form the habit of prioritizing local consumption for Vietnamese customers. Development of the digital era and technological revolution 4.0 is the big chance for all enterprise/business. It contributes to improving production capacity, promoting products, creating potential opportunities in implementing online sales services which are a strong development model during the epidemic. Finally, it is important that businesses proactively come up with the right solutions for themselves to adapt to new markets and employees also actively seek opportunities, hone their skills to adapt to new business model of the market.

AUTHOR CONTRIBUTIONS

HTTN, TTN, VATD, LHN, GTV, and HTL: conceptualization. HTTN, TTN, and VATD: writing original draft. HTTN, TTN, VATD, LHN, GTV, HTL, HTN, and HLTN: writing, review and editing. LHN and GTV: project administration. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Ministry of Health. *COVID-19 Disease Status Statistics 2020*. (2020). Available online at: https://ncov.moh.gov.vn/ (accessed August 14, 2020).
2. Tram B. *Revenue Fell 50%, 2020 Being the Worst Year in Aviation History: 2020*. (2020). Available online at: https://forbesvietnam.com.vn/tin-cap-nhat/doanh-thu-giam-50-2020-la-nam-toi-te-nhat-trong-lich-su-hang-khong-11237.html (accessed August 14, 2020).
3. Rationale and design of a randomized clinical trial on prevention of stroke in isolated systolic hypertension. The systolic hypertension in the elderly program (SHEP) cooperative research group. *J Clin Epidemiol*. (1988) 41:1197–208. doi: 10.1016/0895-4356(88)90024-8
4. Hao S. *Risk Reduction for Informal Workers: Must Start With Labor Policy*. (2020). Available online at: https://baodantoc.vn/giam-rui-ro-cho-lao-dong-phi-chinh-thuc-phai-bat-dau-tu-chinh-sach-ve-lao-dong-1586875740402.htm (accessed August 14, 2020).
5. To H. *Recovery of Production, Business, and Job Keeping for Workers: 2020*. (2020). Available online at: https://nhandan.com.vn/tin-tuc-kinh-te/phuc-hoi-san-xuat-kinh-doanh-giu-viec-lam-cho-nguoi-lao-dong-609247/ (accessed August 13, 2020).
6. General Statistics Office Report on the Impact of COVID-19 Epidemic on Labor and Employment in Vietnam (2020). Available online at: https://www.gso.gov.vn/du-lieu-va-so-lieu-thong-ke/2020/10/bao-cao-tac-dong-cua-dich-covid-19-den-tinh-hinh-lao-dong-viec-lam-tai-viet-nam-quy-iii-2020/ (accessed August 18, 2020).
7. General Statistics Office of Vietnam. *Report on the Impact of the Covid-19 on Labour and Eployment Situation in Vietnam*. (2020).
8. International Labour Organization. *The Time Has Come to Prove that Vietnam Excels in Dealing With Economic Challenges as Well*. (2020). Available online at: https://www.ilo.org/hanoi/Informationresources/Publicinformation/comments-and-analysis/WCMS_741637/lang--vi/index.htm (accessed April 15, 2020).
9. General Statistics Office of Vietnam. *Press Release Labor and Employment Situation in Quarter II and the First 6 Months of 2020*. (2020) 07/10.
10. Nguyen D. Vietnam experiences highest unemployment for a decade due to Covid-19. Vietnam Insider. (2020). Available online at: https://vietnaminsider.vn/vietnam-experiences-highest-unemployment-for-a-decade-due-to-covid-19/ (accessed August 13, 2020)
11. Linh H. The COVID-19 pandemic caused the income of many Vietnamese households to decrease by 70%. Tap chi tai chinh. (2020). Available online at: http://tapchitaichinh.vn/tai-chinh-kinh-doanh/dich-covid19-khien-thu-nhap-cua-nhieu-ho-gia-dinh-viet-nam-giam-toi-70-325853.html
12. Vu L. *Placing Children at the Heart of Viet Nam's COVID-19 Response*. (2020). Available online at: https://www.unicef.org/vietnam/vi/nh?ng-câu-chuy?n/dua-tr?-em-vào-v?-trí-tr?ng-tâm-trong-?ng-phó-v?i-d?ch-covid-19-t?i-vi?t-nam (accessed April 30, 2020).
13. Anh PP. *World Day Against Child Labour 2020: Viet Nam Joins Global Campaign to Confront Intensified Risk of Child Labour Resulting From COVID-19*. (2020). Available online at: unicef.org/vietnam/press-releases/world-day-against-child-labour-2020-viet-nam-joins-global-campaign-confront (accessed December 06, 2020).
14. *Ministry of Finance GDP in the First 6 Months of 2020 Will Reach the Growth Rate of 1.81%*. (2020). Available online at: http://tapchitaichinh.vn/su-kien-noi-bat/gdp-6-thang-dau-nam-2020-dat-muc-tang-truong-181-324929.html (accessed August 25, 2020).
15. General Statistics Office. *Press Release on the Socio-Economic Situation in the Fourth Quarter and 2019: 2019*. (2020). Available online at: https://www.gso.gov.vn/default.aspx?tabid=382&idmid=2&ItemID=19453 (accessed August 25, 2020).
16. Hinh DT. *Some Solutions for Vietnam's Economy During the Covid-19 Pandemic*. (2020). Available online at: https://www.bbc.com/vietnamese/business-52254390 (accessed November 04, 2020).
17. Thoa HT. *Fiscal Solution Dealing With Covid-19*. State Bank of Vietnam (2020).
18. Ministry of Health. *Conclusion of the Politburo on the Policy of Overcoming the Impact of the COVID-19 Pandemic to Restore and Develop the Economy: 2020*. (2020). Available online at: https://ncov.moh.gov.vn/web/guest/-/ket-luan-cua-bo-chinh-tri-ve-chu-truong-khac-phuc-tac-ong-cua-ai-dich-covid-19-e-phuc-hoi-va-phat-trien-nen-kinh-te (accessed August 16, 2020).
19. Nickbakhsh S, Ho A, Marques DFP, McMenamin J, Gunson RN, Murcia PR. Epidemiology of seasonal coronaviruses: establishing the context for the emergence of coronavirus disease 2019. *J Infect Dis*. (2020) 222:17–25. doi: 10.1093/infdis/jiaa185
20. The Vinh. *More than 30 Million Workers Were Affected by the Disease, Unemployment Increased: 2020*. (2020). Available online at: https://tuoitre.vn/news-20200710104857698.htm (accessed July 28, 2020).
21. Bao T. *Economics During Covid-19 Period: 'Vietnam Do Not Expect Eagles': 2020*. (2020). Available online at: https://www.thoibao1000.de/blog/2020/07/14/economics-during-covid-19-period-vietnam-do-not-expect-eagles/ (accessed July 28, 2020).
22. Chinh H. *A Series of Solutions to Support Businesses: The Socialist Republic of Vietnam Online Newpaper of the Government*. (2020). Available online at: http://baochinhphu.vn/Thi-truong/Hang-loat-giai-phap-ho-tro-doanh-nghiep/399631.vgp (accessed February 07, 2020).
23. Ministry of Labour WiaSA. *The Government Raised the Social Security Package to 62 Trillion VND, Supporting About 20 Million People in Need Due to Covid-19: 2020*. (2020). Available online at: http://www.molisa.gov.vn/Pages/tintuc/chitiet.aspx?tintucID=222479 (accessed August 25, 2020).
24. Manh H. *Reducing the Impact of Covid-19 on Vulnerable Groups in Vietnam: 2020*. (2020). Available online at: https://dantri.com.vn/an-sinh/giam-tac-dong-cua-covid-19-len-cac-nhom-de-bi-ton-thuong-tai-viet-nam-20200610160144420.htm (accessed August 14, 2020).
25. International Labour Organization. *Viet Nam Can Well Address Labour Market Challenges: 2020*. (2020). Available online at: https://www.ilo.org/hanoi/Informationresources/Publicinformation/comments-and-analysis/WCMS_741638/lang--en/index.htm (accessed January 09, 2020).
26. The International Labour Organization. *Viet Nam Can Well Address Labour Market Challenges*. (2020). Available online at: https://ilo.org/hanoi/Informationresources/Publicinformation/comments-and-analysis/WCMS_741638/lang--en/index.htm (accessed April 15, 2020).

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Internet of Things and Artificial Intelligence in Healthcare During COVID-19 Pandemic—A South American Perspective

Parag Chatterjee[1,2]*, *Andreína Tesis*[2], *Leandro J. Cymberknop*[1] and *Ricardo L. Armentano*[1,2]

[1] Bioengineering Research and Development Group (GIBIO), Universidad Tecnológica Nacional, Buenos Aires, Argentina,
[2] Department of Biological Engineering, Universidad de la República, Montevideo, Uruguay

The shudders of the COVID-19 pandemic have projected newer challenges in the healthcare domain across the world. In South American scenario, severe issues and difficulties have been noticed in areas like patient consultations, remote monitoring, medical resources, healthcare personnel etc. This work is aimed at providing a holistic view to the digital healthcare during the times of COVID-19 pandemic in South America. It includes different initiatives like mobile apps, web-platforms and intelligent analyses toward early detection and overall healthcare management. In addition to discussing briefly the key issues toward extensive implementation of eHealth paradigms, this work also sheds light on some key aspects of Artificial Intelligence and the Internet of Things along their potential applications like clinical decision support systems and predictive risk modeling, especially in the direction of combating the emergent challenges due to the COVID-19 pandemic.

Keywords: internet of things, artificial intelligence, machine learning, healthcare, ubiquitous, virtual healthcare, COVID-19, pandemic

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***Correspondence:**
Parag Chatterjee
paragc@ieee.org
orcid.org/0000-0001-6760-4704

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INTRODUCTION

Recent years have seen a tremendous surge in domains like the Internet of Things (IoT). The area of healthcare has always been one of the principal application domains of applied IoT. Clubbed with recent advances in Artificial Intelligence (AI) and Machine Learning, eHealth has emerged to new heights in recent times. With the approach of the COVID-19 pandemic, the entire healthcare sector across the world has received shudders from multifarious aspects, including its capacity and deliverability, promptness in response, connected information and analysis. IoT and AI applied to healthcare makes the domain of eHealth largely transdisciplinary, and especially during the times of COVID-19 pandemic, has opened new frontiers of challenges. On one hand, the aspect of eHealth has been fortified in South America during the pandemic by fast development of virtual healthcare solutions. On the other hand, technological areas like IoT and AI have received a strong push to provide fast and efficient healthcare services especially in the perspective of COVID-19, often to automate and facilitate several tasks of the healthcare personnel.

This work is focused on highlighting some of the key aspects of IoT and AI in healthcare related to the domain of South America, especially relevant during the times of COVID-19 pandemic. The principal aspects of eHealth services during COVID-19 in South America have been illustrated, followed by a country-wise review of the state-of-the-art tools and solutions like mobile apps and virtual consultations. Overall, an enormous technological response in healthcare in the South American domain has been noted during the COVID-19 pandemic.

KEY ISSUES IN HEALTHCARE SERVICES DURING COVID-19 PANDEMIC

With the advent of COVID-19, the entire healthcare system in many countries across the world faced the tremendous pressure of the newly infected patients. Added to the pressure was the extremely critical protocols (1) of water, sanitation, hygiene, and waste management, maintaining which implied new challenges in handling patients in the hospitals and healthcare centers. However, these challenges during the times of pandemic opened new possibilities for IoT and AI in the domain of healthcare. IoT is basically an interconnection of different objects, mostly heterogenous, to share important data among each other, aiming to provide more efficient services to the users. Artificial Intelligence on the other hand contributes significantly in making sense of the huge data accumulated from various sources by processing it and applying intelligent analytics to get deeper insights, in addition to providing smart services to the stakeholders. Since the inception of the COVID-19 pandemic, the healthcare sector in the entire South America faced several challenges, the principal ones being the shortage of human resources in essential healthcare services, arrangement of treatments for usual patients, and suddenly surged demand of specific medical supplies.

Healthcare Personnel

The crisis occurred due to the COVID-19 pandemic resulted in a shortage of available medical staff to treat the usual patient population. Due to the shortage, special efforts were taken by several countries to address the sudden surge in the need of physicians in the healthcare system. Several South American countries like Argentina, Uruguay, Chile and Venezuela have formed cooperation between the university faculties of medicine and state healthcare authorities to invite and engage medical students in the combat of COVID-19 on one hand, and summoned retired physicians to join the existing healthcare staff during the pandemic (2–7). For example, in Uruguay, retired physicians were invited for voluntary participation in the follow-up of patients under home-quarantine through tele or videoconference. Also, there has been a movement of physicians between countries to handle the shortage of healthcare staff due to the pandemic's effect on the healthcare system (8).

Patient Follow-Up

Due to the added risk of contamination and to reduce gatherings in hospitals and healthcare centers, the aspect of remote healthcare especially for the existing non-critical patients stood highly important. Also, to free up healthcare resources for the critical COVID-19 patients, most of the non-critical patients with other diseases were advised to avoid hospital visits (9). Clearly, this involved a disruption in the usual treatment and follow-up of the existing non-COVID patients, leading to newer challenges in maintaining a necessary level of treatment and follow-up on one hand, and keep provisions for COVID-19 patients on the other hand.

Medical Resource Shortage

Due to non-uniform geographical distribution of the COVID-19 cases, there has been frequent need of sharing and interprovincial transportation of medical supplies among different healthcare facilities in a dynamic manner based on the progression of COVID-19 cases, to avoid shortage at a specific facility with high demand. To avoid the shortage of essential medical devices like respirators and rapid test kits, several collaborations have been established between academia and industry, for the development of devices like artificial respirators or UV-based sterilizing devices (10, 11).

PRINCIPAL APPLICATIONS OF IoT AND AI IN VIRTUAL HEALTHCARE—SOUTH AMERICAN PERSPECTIVE

The application domain of Artificial Intelligence in healthcare is extremely wide. In addition to intelligent analytics and decision-making, AI and IoT have specific advantages in eHealth during the emergent situations due to COVID-19. Especially in South America, where challenges in healthcare are multifarious like inequalities in healthcare access, healthcare quality, demographic and epidemiological changes in the population (12), the situation due to COVID-19 created a substantial pressure on the healthcare system. But this opened a vast potential for applying eHealth, making the relevance of IoT and AI paramount. Especially in the perspective of COVID-19, several aspects of eHealth using IoT and AI can be applied for improved treatment and monitoring and better management of healthcare services during the pandemic times.

Virtual Consultations and Remote Monitoring With IoT Devices

To avoid the hospital visits and reduce the conglomeration of non-critical patients in healthcare facilities during COVID-19, several South American countries have started virtual consultation systems through their public healthcare system (**Table 1**). On one hand, some countries enhanced their existing telehealth platforms, and on the other hand, dedicated virtual consultation channels were opened attributed to the pandemic. It is mostly performed through telephone calls or videoconferencing or even through messages, but without an extensive usage of remote monitoring devices.

However, the system of virtual consultation is primarily built on the foundation of verbal reporting of the symptoms by the patient and the physician's diagnoses based on that. A key to efficient diagnosis is the knowledge of different health indicators in addition to the detailed symptoms reported by the patient. But through telephone calls or videoconferencing, this stands as a substantial challenge, as in virtual consultations, the physician has to entirely depend on the reported symptoms. Also, it raises the possibilities of patients lacking confidence in the diagnosis since it is prepared without any precise knowledge of the health indicators.

TABLE 1 | State of virtual consultations during COVID-19 in South America.

Country	State of virtual consultation with physicians during COVID-19
Argentina	The *Tele-Covid* service was launched in the context of COVID-19, enabling people covered under public healthcare system to perform consultations to medical specialists through video-calling. Apart from supporting the follow-up of people affected by COVID-19, it also extends support to other risk groups like people with chronic diseases, pregnant women, newborns, children under 1 year of age, people with disabilities and those requiring psychological support (13).
Bolivia	A telemedicine initiative *(Telesalud Bolivia)* was undertaken with the aim of reaching the entire population, including call centers, and resources for training for respective stakeholders (14).
Brazil	A strong initiative was taken including the approval of a national law to use telemedicine during COVID-19 and also in the future, dealing with technology-linked healthcare, research, and prevention of diseases. Also, the *RadVid-19*, an artificial intelligence tool to identify different areas estimating the probability of a COVID-19 case was introduced (15, 16).
Chile	A new model of telehealth *Hospital Digital* was established (with upcoming features like access to personal clinical history and EHR), in addition to the initiatives under National Digital Strategy of Healthcare (17).
Colombia	The telemedicine model supported in relieving the pressure of the healthcare system during the pandemic by offering services like teleconsultations and delivery of medicines to more than 30 million people, in addition to existing telehealth initiatives like TeleUCI, for remote intensive care units (18).
Ecuador	Through the telemedicine platform, patients are provided access to specialist physicians virtually (even through Zoom or WhatsApp for the private system). Especially during the pandemic, the call center also complemented the telemedicine platform for general queries (19).
Guyana	Several initiatives have taken since the last few years for universal healthcare and a better outreach. Apart from specific telemedicine missions, websites were designed especially during COVID-19 with personalized chat options for specific support.
Paraguay	The implementation of telemedicine was aimed at in a pre-pandemic scenario to universalize health services. In addition to enabling carrying out different procedures online, a remote monitoring service for supplies and medicines was set up (20). Also applied research was performed on virtual healthcare platforms toward universal healthcare coverage, through diagnostic imaging studies of tomography and ultrasound, and other biological electrical signals like Electrocardiogram (ECG) and electroencephalogram (EEG) and evaluating the mechanism of sharing the information with specialists for diagnosis.
Peru	The telemedicine platform *TeleSalud* is aimed at facilitating virtual consultations with specialists across Skype or Zoom, primarily by establishing link between different stakeholders of the healthcare system (21).
Suriname	Rural telecommunication network expansion and enhancement programs were undertaken previously to increase the reach of services like telehealth. However, currently no substantial instances of virtual consultations were noted.
Uruguay	People with symptoms of COVID-19 have direct access to online healthcare portal, leading to FAQs and other essential support. For non-COVID cases as well, the telehealth system is accessible for virtual consultations with medical specialists, and other usual services like scheduling appointments and access to personal clinical history.
Venezuela	Despite issues with the shortage of resources for telemedicine, the usage of social media for virtual consultations has seen a sharp increase, often used as an alternative medium of communication with the physicians (22).

IoT-eHealth devices hold the potential to play a significant role in this area. It aims at monitoring patients remotely from their homes using smart healthcare devices, to avoid or minimize their hospital visits on one hand, and to provide more accurate health-information to the physicians before or during virtual consultations. IoT-eHealth devices are usually capable of measuring several health parameters like heart rate, blood pressure, temperature, blood glucose etc. right from the patient's home and send summarized information to the medical personnel, to facilitate their diagnosis and treatment. For example, significant surge has been seen in the usage of devices like pulse oximeters in the COVID-19 scenario, to monitor blood oxygen levels (SpO_2) at home itself. Especially during the times of COVID-19, the usage of smart healthcare devices through IoT platforms is proposed, as it ensures better visibility of the patients' health to the physicians during the virtual consultations and also facilitates more accurate and efficient treatment.

Early Detection, Diagnosis, and Management Using Artificial Intelligence

Due to the COVID-19 pandemic, almost all the countries in South America faced an enormous load in the healthcare system. This involved scarcity of resources like medical staff, or even space in hospital and healthcare facilities. This opened a strong need to automate the basic decision-making processes for providing advice to the patients (35–38). AI plays an important role in this aspect, especially supporting physicians in early detection of COVID-19 cases by quickly analyzing irregular symptoms and other suspicions and thus alert the respective stakeholders like the patients and healthcare authorities (39).

Almost all the countries in South America have developed mobile applications and web-platforms to analyze the symptoms provided by people and matching it with predesigned decision trees, to provide specific advice related to COVID-19 (**Table 2**). Using IoT-eHealth devices counts more significant in this domain because of its more precision in reporting health indicators remotely and its potential in facilitating the automated decision-making process through. Since the quality of input health-data to the intelligent models through smart eHealth devices would be better than just self-reporting of symptoms, the advice would be more specific, personalized and efficient. Clinical decision support systems hold the potential to provide fast and automatic primary responses to the patients based on the health-data obtained (**Figure 1**), saving significant resources like time and personnel in the rush-hours and times of pandemic.

TABLE 2 | Mobile and web-apps in South America for early detection of COVID-19.

Country	Mobile Apps during COVID-19
Argentina	The *Cuidar* mobile app (23) enables self-diagnosis for people based on manual entry of symptoms, provides assistance and recommendations in the case of contagion and provides contact-tools for these cases to health authorities. The application is linked to a broader system that articulates the collected information with the health-authorities in charge of emergency care, both for the national and provincial governments. In this way, the app complements and assists the prevention and care policies for the population and, in particular, provides specific elements and supplies for the health intervention of the Ministries of Health throughout the national territory of Argentina.
Bolivia	The *Coronavirus Bolivia* app includes comprehensive information on symptoms, official communications, notices, information, emergency contacts and FAQs (24).
Brazil	The *Coronavirus-Sus* app was launched with the purpose of alerting people regarding the situation through information on diverse topics like possible symptoms, preventive measures, or detection in case of symptoms. In case of suspected infection, it can be checked if the symptoms are compatible with COVID-19, and if so, instructions are provided, referring to the nearest basic healthcare facility (25).
Chile	The *CoronApp* includes health status reporting, daily monitoring of symptoms, controlling the quarantine, resolving doubts and reporting risk situations to prevent infections, in addition to providing updated information from the health authorities (26). It has a virtual assistant based on artificial intelligence to answer general queries by WhatsApp, or by phone call, contacting the healthcare authorities. In addition, using geolocation of the phone, the app has been enabled to send alerts and notifications to people if they leave their quarantine zone, and reporting of risk situations in the form of crowds, events and improper conduct. The motive is a collaborative care system in connection with the health authorities and administrations to take quick actions in risky situations.
Colombia	The *Coronapp* is a free app that does not consume data and it helps in the detection of affected areas and nearby people with a positive diagnosis for COVID-19. Also, it facilitates the real-time monitoring of data collected at the Emergency Operations Center of the National Health Institute (INS), so that they can act quickly and provide support in coordination with local, departmental and national authorities (27).
Ecuador	The *SaludEc* app is oriented to meet several objectives. It is aimed at evaluating people's symptoms to flag possible cases or rule out the possibilities. It is also a way to send official information timely through digital channels and reduce the load on channel 171. It puts forward a telemedicine channel to complement the already established channels. Also, it enables the scheduling of medical appointments in the first level health centers of the Ministry of Public Health in specialties not related to the coronavirus such as General Medicine, Psychology, Obstetrics and Dentistry (28).
Guyana	With the objective of improving the response of the ministry to reports of suspected cases of COVID-19, the Ministry of Public Health has launched an online app, providing self-screening facilities based on symptoms, in addition to regular recommendations and alerts, and other useful information like hotline numbers and periodic information on COVID-19 (29).
Paraguay	The *COVID-19 PY* platform is aimed exclusively at people who are in isolation and health personnel to connect through the web-app. It offers daily medical self-reporting by people in home-quarantine and if symptoms are detected, corresponding recommendations are provided. Also monitoring and follow-up of people in quarantine is performed using geolocation for greater efficiency in the control of data of people in isolation (30).
Perú	The *Perú en tus manos* app shows a heatmap with red circles in the areas with already infected people and with orange circles where there are people with registered symptoms of COVID-19. Additionally, the app gives people the possibility of carrying out a digital triage oriented to the epidemiological alert to find out if they are at risk of having transmitted the coronavirus. Likewise, an important functionality has been developed for patients affected by COVID-19 under compulsory social isolation, enabling them to report their health status and update their symptoms regularly, so that the members of the *'Te Cuido Peru'* Group in coordination with the Ministry of Health can attend them in a timely way. In this way, they also receive a daily summary and follow-up of their health condition and will know if their health has deteriorated. If necessary, health specialists can contact the affected person to provide immediate care if needed (31).
Suriname	A dedicated website for COVID-19 has been developed, primarily for the dissemination of official information and guidelines related to the disease, in addition to reporting systems integrated with the website (32).
Uruguay	The mobile app *Coronavirus UY* allows to connect citizens with possible symptoms of COVID-19 with the healthcare providers, in order to reduce waiting times for consultations and attention during the state of health emergency in Uruguay, and provide other uses like visualization of information across the country, reporting of symptoms, telemedicine consultation and exposure alerts. Exposure alert is a valuable tool both for people (to be able to quickly find out about a certain risk of contagion) and for the authorities, in terms of monitoring and responding to the appearance of specific sources of contagion. In order to provide total transparency and guarantees on the management of the information collected, in this first stage, the national-level stakeholders (academia, industry, organized civil societies) were given the possibility of auditing the documentation and source code of the Coronavirus UY app, including its exposure alert functionalities (33).
Venezuela	A COVID-19 screening survey through the mobile *Patria* system was launched, enabling people to report the appearance of symptoms related to the disease, facilitating the follow-up by authorities (34).

Connected Electronic Health Records (EHRs)

The advantage of the electronic health-data acquired by the IoT-eHealth devices lies in its transferability and processability. The IoT offers a sharing platform so that the EHR collected from the patients' eHealth devices can be shared across multiple heterogeneous devices, and across health networks in an easily accessible way to the healthcare providers. In South America, several countries have developed models for shareable EHR, enabling seamless exchange of EHR between healthcare providers as well as administrative entities. Primarily it deals with electronic versions of medical reports, physician's prescriptions and other information of patients stored online, making it easy to access for the patients avoiding visits to healthcare facilities and also for the healthcare personnel to provide remote treatment more efficiently. With the advent of COVID-19, the need of

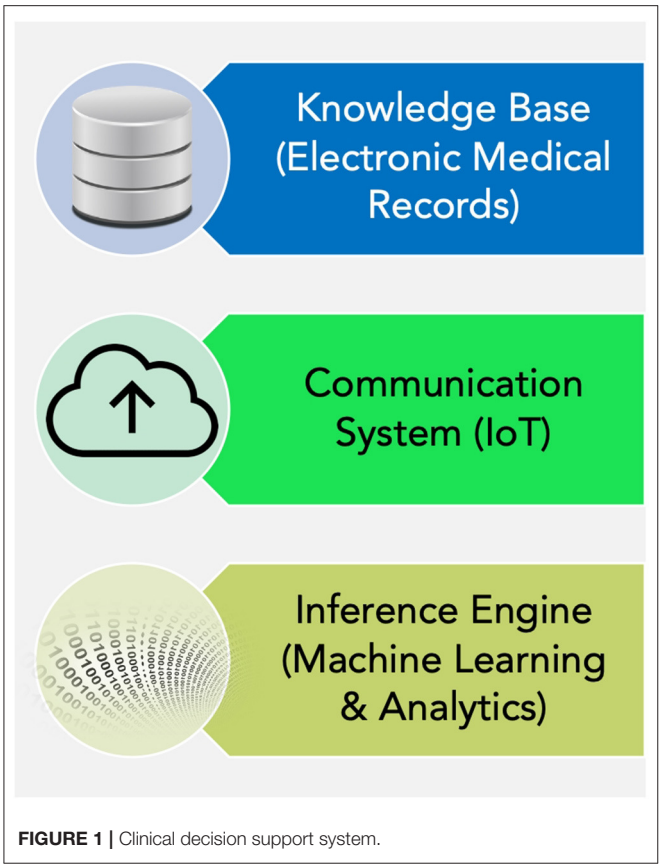

FIGURE 1 | Clinical decision support system.

sharing health-data has increased significantly, in order to share important aspects of the disease outbreaks, compare symptoms across different regions and healthcare facilities and to understand the comprehensive scenario. IoT supports this scenario through multilayered sharing of EHR among different stakeholders, to provide comprehensive support to the patients.

Especially during the times of COVID-19, shareable and comprehensively accessible EHR enables to design a detailed risk-profiling of the population in almost real-time, using clustering algorithms. Also, it helps in deciphering the health-trend of the population mostly through supervised predictive models, strongly important in day-to-day planning and decisions on healthcare services during the pandemic.

Priority Scheduling of Patients

After the first effect of COVID-19 pandemic, as several healthcare facilities started opening for usual healthcare services in different South American countries, one of the key challenges is to manage the huge list of waiting patients who had to avoid visits the hospitals during the times of lockdown. The handling of patient-queues and priority lists is important, as delays in patients with potential risk could be fatal and due to limited resources of healthcare facilities, prioritization should be done efficiently and accurately. AI can process the comprehensive health-data of patients, including the previous hospital visits, laboratory results and interim treatments or complications, and use machine learning to train models and generate priority lists of patients to facilitate the medical staff in attending usual patients after lockdown.

Resource Sharing and Policymaking

AI plays a significant role in resource optimization. Especially in the crisis of resources and medical supplies in the times of COVID-19 pandemic, applying unsupervised learning techniques like clustering is useful to identify the key clusters and overall situation of resources across different centers, followed by distribution algorithms to share the resources efficiently. It is useful in different aspects of policymaking in emergency situations. Also, it can be used to predict the shortage of resources and supplies with considerable anticipation, giving enough time to organize the transfer and management of resources in combating the shortage.

CONCLUSION

The domain of healthcare has been one of the fastest adopting sectors for IoT and AI (40–47). Especially in the times of COVID-19 pandemic, the entire healthcare sector faced new challenges. In this context, several opportunities for application of IoT and AI have been discussed pertaining to a South American perspective. It includes efficient virtual consultations and remote monitoring of patients, intelligent diagnoses, sharing EHRs, and priority scheduling for patients. Several countries in South America face challenges in areas like digital-divide and disparity in population having access to digital technologies toward healthcare. Apart from that, despite having other challenges like limited power in handling big data, interoperability of health-data among heterogeneous stakeholders, and lack of unified implementational structure for eHealth, AI and IoT put forward immense potential in the healthcare sector, especially during and after the COVID-19 pandemic.

AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct and intellectual contribution to the work, and approved it for publication.

REFERENCES

1. Water, sanitation, hygiene, and waste management for the COVID-19 virus: interim guidance. *World Health Organization, 23-Apr-2020*. (2020) Available online at: https://www.who.int/publications/i/item/water-sanitation-hygiene-and-waste-management-for-covid-19 (accessed June 22, 2020).
2. La UBA reclutó 4 mil voluntarios para combatir el coronavirus en sólo 24 horas. *Infobae, 24-Mar-2020*. (2020) Available online at: https://www.infobae.com/educacion/2020/03/24/la-uba-recluto-4-mil-voluntarios-para-combatir-el-coronavirus-en-solo-24-horas/ (accessed June 22, 2020).
3. Facultad de Medicina convoca a estudiantes a ser voluntarios en actividades de UdelaR y ASSE. *Diario EL PAIS Uruguay, 26-Mar-2020*. (2020) Available online at: https://www.elpais.com.uy/informacion/educacion/facultad-

medicina-convoca-estudiantes-voluntarios-actividades-udelar-asse.html (accessed June 22, 2020).
4. Convocan a médicos jubilados para atender a distancia a pacientes de ASSE con coronavirus. (2020) Available online at: https://www.colegiomedico.org.uy/prensa/convocan-a-medicos-jubilados-para-atender-a-distancia-a-pacientes-de-asse-con-coronavirus-montevideo-portal/ (accessed August 13, 2020).
5. Coronavirus: Metro sanitiza los trenes y habilitarán un registro de pasajeros de buses interurbanos. *CNN Chile*. (2020) Available online at: https://www.cnnchile.com/pais/coronavirus-metro-sanitiza-trenes-buses-registro-pasajeros_20200306/ (accessed June 22, 2020).
6. Llaman a estudiantes de medicina ante la lucha contra el coronavirus. *EXPRESO*, *01-Apr-2020*. (2020) Available online at https://www.expreso.com.mx/seccion/sonora/167877-llaman-a-estudiantes-de-medicina-ante-la-lucha-contra-el-coronavirus.html (accessed June 22, 2020).
7. Gobierno Bolivariano llama a estudiantes de medicina y a profesionales jubilados de la salud a sumarse en el combate contra el COVID-19. *Vicepresidencia de la República Bolivariana de Venezuela*. (2020) Available online at: http://vicepresidencia.gob.ve/gobierno-bolivariano-llama-a-estudiantes-de-medicina-y-a-profesionales-jubilados-de-la-salud-a-sumarse-en-el-combate-contra-el-covid-19/ (accessed June 22, 2020).
8. Vassigh A. Bracing For COVID-19. *Argentina Calls On Cuban Doctors*. (2020). Available online at: http://worldcrunch.com/coronavirus/bracing-for-covid-19-argentina-calls-on-cuban-doctors (accessed April 27, 2020).
9. Available online at: http://www.msal.gob.ar/images/stories/bes/graficos/0000001939cnt-covid-19-recomendaciones-consulta-medica-programada.pdf
10. Intendencia de Paysandú, "*Generan Prototipo de Respirador Artificial en el Hacklab de Paysandú Innova*," (2020) Available online at: https://www.paysandu.gub.uy/destacadas/9638-generan-prototipo-de-respirador-artificial-en-el-hacklab-de-paysandu-innova (accessed August 13, 2020).
11. ElRionegrense, "*UTEC Desarrolla Dispositivo Para Combatir COVID-19*," *El Rionegrense - Noticias Fray Bentos Diario Digital Rio Negro Uruguay*, 28-Apr-2020. (2020) Available online at: https://www.elrionegrense.com.uy/2020/04/28/utec-desarrolla-dispositivo-para-combatir-covid-19/ (accessed August 13, 2020).
12. Fernández A, Oviedo E. *e-Health in Latin America and the Caribbean: Progress and Challenges Jul-2011*. (2020) Available online at: https://repositorio.cepal.org/bitstream/handle/11362/35326/S2011027.pdf?sequence=1&isAllowed=y (accessed June 24, 2020).
13. Argentina Unida, "*Lanzamiento de Tele-Covid: el Servicio de Telemedicina Destinado a Personas Con Cobertura Estatal Exclusiva*," *Argentina.gob.ar*, 26-May-2020. (2020) Available online at: https://www.argentina.gob.ar/noticias/lanzamiento-de-tele-covid-el-servicio-de-telemedicina-destinado-personas-con-cobertura (accessed August 13, 2020).
14. Telesalud, "*Telesalud Bolivia*," *Programa Nacional de Telesalud*. (2020) Available online at: https://ts.minsalud.gob.bo/ (accessed August 13, 2020).
15. Available online at: https://www.batimes.com.ar/news/latin-america/ai-helps-doctors-fight-covid-19-in-brazil.phtml
16. Available online at: https://digitalpolicylaw.com/entra-en-vigor-la-ley-de-telemedicina-en-brasil-durante-covid-19/
17. Toro L, Parra A, Alvo M. Epidemia de COVID-19 en chile: impacto en atenciones de servicios de urgencia y patologías específicas. *Revista Méd Chile*. (2020) 148:558–60. doi: 10.4067/s0034-98872020000400558
18. Figueroa LM. Telehealth in Colombia, challenges associated with COVID-19. *Biomédica*. (2020) 40:77–9. doi: 10.7705/biomedica.5594
19. Gracias a la telemedicina, consultas no se detienen durante emergencia. *El Comercio*. (2020). Available online at: https://www.elcomercio.com/actualidad/telemedicina-consultas-emergencia-salud-coronavirus.html (accessed August 13, 2020).
20. Ministerio de Salud, "Monitoreo de Insumos y Medicamentos," *Ministerio de Salud Publica y Bienestar Social*. (2020) Available online at: https://www.mspbs.gov.py/monitoreo-insumos-medicamentos.html (accessed August 13, 2020).
21. "TeleSalud," *TelemedicinaPerú*. (2020) Available online at: https://telemedicinaperu.com/ (accessed August 13, 2020).
22. "Telemedicina alivia sinsabores de la pandemia en Venezuela," *Voice of America*. (2020) Available online at: https://www.voanoticias.com/venezuela/telemedicina-alivia-sinsabores-pandemia-venezuela (accessed August 13, 2020).
23. "Sistema y aplicación Cuidar," *Argentina.gob.ar*, 22-Jun-2020. (2020) Available online at: https://www.argentina.gob.ar/jefatura/innovacion-publica/acciones-coronavirus/aplicacion-y-tableros-de-gestion (accessed August 14, 2020).
24. Bolivia Segura. *Autoevaluación COVID-19 Bolivia Segura*. (2020) Available online at: https://www.boliviasegura.gob.bo/autoevaluacion.php (accessed August 27, 2020).
25. "Coronavírus - SUS," *Coronavírus - SUS* - Brasil. (2020) Available online at: https://www.gov.br/pt-br/apps/coronavirus-sus (accessed August 15, 2020).
26. "CoronApp: La nueva aplicación de Chile para combatir la pandemia," *División de Gobierno Digital*. (2020) Available online at: https://digital.gob.cl/noticias/coronapp-la-nueva-aplicacion-de-chile-para-combatir-la-pandemia (accessed August 15, 2020).
27. "Coronapp," *El Coronavirus en Colombia*. (2020) Available online at: https://coronaviruscolombia.gov.co/Covid19/aislamiento-saludable/coronapp.html (accessed August 15, 2020).
28. "El Presidente Lenín Moreno presentó al país la app SaludEc," *Ministerio de Telecomunicaciones y de la Sociedad de la Información*. (2020) Available online at: https://www.telecomunicaciones.gob.ec/el-presidente-lenin-moreno-presento-al-pais-la-app-saludec/ (accessed August 15, 2020).
29. "Ministry of Public Health's Information System for the fight against COVID-19," *Covid19 Outbreak Tracker*. (2020) Available online at: https://covid19.health.gov.gy/apps/moph/r/outbreak/1000 (accessed August 15, 2020).
30. "Lanzan App exclusiva para pacientes en cuarentena y personal de blanco," *Ministerio de Salud Publica y Bienestar Social*. (2020) Available online at: https://www.mspbs.gov.py/portal/20679/lanzan-app-exclusiva-para-pacientes-en-cuarentena-y-personal-de-blanco.html (accessed August 15, 2020).
31. Oficina de Prensa e Imagen Institucional, "Gobierno lanza nueva versión de app" *Gobierno del Perú*. (2020) Available online at: https://www.gob.pe/institucion/pcm/noticias/150943-gobierno-lanza-nueva-version-de-app-peru-en-tus-manos-para-advertir-a-los-ciudadanos-sobre-las-zonas-con-mayor-probabilidad-de-contagio (accessed August 15, 2020).
32. "Ontslagcriteria voor gehospitaliseerde COVID-19 patiënten," *Covid Suriname*. (2020) Available online at: https://covid-19.sr/ontslagcriteria-voor-gehospitaliseerde-covid-19-patienten/ (accessed August 15, 2020).
33. "Información sobre la Aplicación Coronavirus UY," *Ministerio de Salud Pública*. (2020) Available online at: https://www.gub.uy/ministerio-salud-publica/politicas-y-gestion/informacion-sobre-aplicacion-coronavirus (accessed August 15, 2020).
34. "Información sobre la Aplicación Coronavirus UY," *Ministerio de Salud Pública*. (2020) Available online at: https://www.gub.uy/ministerio-salud-publica/politicas-y-gestion/informacion-sobre-aplicacion-coronavirus Available online at: https://reliefweb.int/sites/reliefweb.int/files/resources/20200407_VEN_Covid-19_Flash_Update_No2_EN.pdf (accessed August 15, 2020).
35. Chatterjee P, Armentano RL. Internet of things for a smart and ubiquitous ehealth system. In: *2015 International Conference on Computational Intelligence and Communication Networks (CICN)*. Jabalpur: IEEE (2015). p. 903–7. doi: 10.1109/CICN.2015.178
36. Chatterjee P, Cymberknop LJ, Armentano RL. IoT-based decision support system for intelligent healthcare — applied to cardiovascular diseases. In: *2017 7th International Conference on Communication Systems and Network Technologies (CSNT)*. Nagpur: IEEE (2017). p. 362–6. doi: 10.1109/CSNT.2017.8418567
37. Chatterjee P, Armentano RL, Cymberknop LJ. Internet of things and decision support system for ehealth - applied to cardiometabolic diseases. In: *2017 International Conference on Machine Learning and Data Science (MLDS)*. Noida: IEEE (2017). p. 75–9. doi: 10.1109/MLDS.2017.22
38. Chatterjee P, Cymberknop LJ, Armentano RL. IoT-based ehealth toward decision support system for CBRNE events. In: A. Malizia and M. D'Arienzo eds *Enhancing CBRNE Safety & Security: Proceedings of the SICC 2017 Conference*. Springer (2018) 183–188. doi: 10.1007/978-3-319-91791-7_21
39. Vaishya R, Javaid M, Khan IH, Haleem A. Artificial Intelligence (AI) applications for COVID-19 pandemic. *Diabetes Metab Syndr Clin Res Rev*. (2020) 14:337–9. doi: 10.1016/j.dsx.2020.04.012

40. Armentano R, Bhadoria RS, Chatterjee P, Deka GC. *The Internet of Things: Foundation for Smart Cities, eHealth and Ubiquitous Computing*. Boca Raton: CRC Press (2017).
41. Chatterjee P, Cymberknop LJ, Armentano RL. Nonlinear systems in healthcare - a perspective of intelligent disease prediction. *Nonlinear Syst IntechOpen.* (2019) 2. doi: 10.5772/intechopen.88163
42. Chatterjee P, Armentano R, Palombi L, Kun L. Editorial preface: special issue on IoT for eHealth, elderly and aging. *Intern. Things.* (2019). doi: 10.1016/j.iot.2019.100115
43. Singh Y, Patel H, Deepa JMRS, Tavares, Salahddine K, Chatterjee P, Hu W et al. Machine learning integration in cardiac electrophysiology. *J Adv Res Dyn Control Syst*. (2020) 12:942–4. doi: 10.5373/JARDCS/V12SP4/20201565
44. Chatterjee P, Nath A. Biometric authentication for UID-based smart and ubiquitous services in India. In: *2015 Fifth International Conference on Communication Systems and Network Technologies*. Gwalior: IEEE (2015). doi: 10.1109/csnt.2015.195
45. Chatterjee P, Cymberknop L, Armentano R. *IoT-Based Decision Support System Towards Cardiovascular Diseases*. Córdoba, Argentina: SABI (2017).
46. De Luca MA, Cymberknop LJ, Mayer I, Percunte MD, Arbeitman CR, Chatterjee P, et al. Device for the evaluation of carotid arterial pressure based on IoT and 3D-printing: uFISIO. *Revista Argentina de Bioingeniería*. (2020) 24:9–14. doi: 10.1007/s12553-016-0148-0
47. Romero LE, Chatterjee P, Armentano RL. An IoT approach for integration of computational intelligence and wearable sensors for parkinson's disease diagnosis and monitoring. *Health Technol.* (2016) 6:167–72.

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Workforce Mobilization From the National Institutes of Health for the Ministry of Health Malaysia: A COVID-19 Pandemic Response

Abdul Rassip Muhammad Nur Amir[1], Awatef Binti Amer Nordin[2], Yin Cheng Lim[3], Nor Izzah Binti Ahmad Shauki[2] and Nor Hayati Binti Ibrahim[1]*

[1] *Institute for Health Management, Ministry of Health Malaysia, Shah Alam, Malaysia,* [2] *Institute for Health System Research, Ministry of Health Malaysia, Shah Alam, Malaysia,* [3] *Institue for Medical Research, Ministry of Health Malaysia, Shah Alam, Malaysia*

The COVID-19 pandemic that emerged in 2019 has inflicted numerous clinical and public health challenges worldwide. It was declared a public health emergency by the World Health Organization and activated response teams at almost all Malaysian healthcare facilities. Upon activation of the National Crisis Preparedness and Response Center in January 2020, the National Institutes of Health Malaysia established a COVID-19 operation room at the facility level to address the rise in COVID-19 infection cases each day. The National Institutes of Health COVID-19 operation room committee formed a workforce mobilization team for an effective and efficient mobilization system to fulfill requests received for human resource aid within the Ministry of Health Malaysia facilities. Selected personnel would be screened for health and availability before mobilization letters and logistics arrangements if necessary. The workforce from the National Institutes of Health, consisting of various job positions, were mobilized every week, with each deployment cycle lasting 2 weeks. A total of 128 personnel from the six institutes under the National Institutes of Health were mobilized: tasks included fever screening, active case detection, health management at quarantine centers, and management of dead bodies. A well-organized data management system with a centralized online system integration could allow more rapid deployment and answer some of the key questions in managing a similar pandemic in the future. With improving infected COVID-19 cases throughout the country, the National Institutes of Health COVID-19 operation room was effectively closed on June 15, 2020, following approval from the Deputy Director-General of Health.

Keywords: COVID-19 pandemic, data management, Ministry of Health Malaysia, National Institutes of Health Malaysia, workforce mobilization

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****Correspondence:***
Abdul Rassip Muhammad Nur Amir
nur.amir@moh.gov.my
orcid.org/0000-0002-8162-1380

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INTRODUCTION

COVID-19 is an infectious disease caused by a newly discovered coronavirus that reportedly emerged in Wuhan city, China, in December 2019. This novel coronavirus's causative agent was in January 2020 found to be of the same subgenus as the Severe Acute Respiratory Syndrome Coronavirus (SARS-CoV). As of September 17, 2020, there were a total of 29,656,504 COVID-19

cases worldwide, with 936,905 deaths reported (1). The World Health Organization (WHO) declared COVID-19 a pandemic on March 11, 2020, making it a public health emergency of international concern (2). Cases have been reported virtually in all continents and have been steadily increasing in many countries. The three countries most impacted by COVID-19 include the United States of America (USA), which reported cases to surpass 6 million, followed by India and Brazil, with more than 9 million combined cases. On September 17, 2020, Malaysia had more than 10,000 confirmed cases of COVID-19, with 128 deaths and among the highest number of coronavirus infections in Southeast Asia (3).

This ongoing outbreak poses many clinical and public health management challenges because of limited understanding of viral pathogenesis; infection risk factors; disease clinical presentation and outcomes; prognostic factors for severe illness; the infectivity period; modes and range of virus inter-human transmission; effective preventive measures as well as public health response; and containment interventions (4). Extra efforts need to be in place to prevent and control the spread of an infectious disease or pandemic. The healthcare system changes during a pandemic, whereby shortages of medical personnel, staff illnesses, or limitations in the availability of equipment or intensive-care unit capacity becoming the major triggering factors (5).

The first wave of COVID-19 outbreak in Malaysia began with the emergence of the first confirmed case detected on January 24, 2020. Up until mid-February, Malaysia recorded 22 cases of COVID-19. The Ministry of Health (MOH) Malaysia activated the National Crisis Preparedness and Response Center (CPRC) in January 2020 under the Surveillance Section of the Disease Control Division to ensure effective management of disasters, outbreaks, crises, and emergencies (DOCE) related to health. After the second wave of COVID-19 in Malaysia, which occurred in late February 2020, the MOH Malaysia recognized a need for workforce reinforcements, essentially targeted screening within the community and International Points of Entry. Hence, the CPRC aims to provide short-term relief and strategize on mobilizing ancillary medical and health personnel along with volunteers from the MOH Malaysia, government and non-governmental bodies, private sectors, and individuals as part of the public health response to areas with the highest burden of COVID-19.

THE SUDDEN SURGE

Malaysia was able to report 11 days of zero confirmed cases consecutively, from February 16 to 26, 2020, until the second wave began February 27, 2020. On March 11, 2020, Malaysia experienced a sharp increase in new cases after the International Health Regulations (IHR) Focal Point for Brunei told the Malaysian IHR Focal Point that the country had discerned a positive case traveling to Malaysia to attend a religious mass meeting. The meeting was held from February 27 to March 1, 2020, involving approximately 16,000 participants, of which about 14,500 participants were Malaysians. More than 100 cases have been registered daily since March 15, 2020, with most patients having a history of attending the mass meeting or some manner of contact with the attendees (6). Subsequently, on March 17, 2020, Malaysia recorded the first two COVID-19-related deaths, with one case being associated with the religious gathering.

In mid-March, the rampant outbreak suggested that Malaysia was in the late containment phase and required swift and more aggressive measures to contain the disease. Consequently, the Malaysian government instituted a Movement Control Order (MCO) from March 18 to March 31, 2020, intending to break the community's COVID-19 chain. The MCO was further extended in phases until May 3, 2020, as the number of positive cases remained relatively high. In many specific locations that reported a sudden rise in cases, the Malaysian government introduced Enhanced MCO (EMCO). With Conditional MCO (CMCO) (May 4 to June 9, 2020) and Recovery MCO (RMCO) (June 10 to August 31, 2020) implemented sequentially, the four-phase MCO has nearly flattened the curve and decreased the active cases to an amount that does not overwhelm the healthcare system.

CONTEXT – SETTING AND POPULATION

Coordination of Country Response

Malaysia initiated a response to COVID-19 as soon as the news broke of a new pneumonia-causing virus in Wuhan, China, on January 2, 2020. After corresponding with the WHO Country Office as well as the WHO Regional Office, Malaysia's IHR focal point shifted to evaluating the risk of occurrence in Malaysia. Subsequently, on January 5, 2020, Malaysia's IHR focal point began collecting information through the WHO Events Information Site (EIS), a safe web-based communications portal between the WHO and the National IHR focal point. *Via* the EIS, the WHO Secretariat exchanged information and communication regarding acute public health risks with potentially global ramifications. Based on the information and risk assessment provided by the WHO-EIS, Malaysia's IHR focal point conveyed the information to the Director-General of Health, all Deputy Directors of Health, relevant program directors in the MOH, as well as other relevant ministries, such as the Department of Veterinary Affairs. Then, an urgent meeting of the Disaster Management Technical Committee took place to coordinate Malaysia's preparedness and response.

Malaysia's IHR focal point provides leverage in its response by frequently communicating with the National IHR focal points from other countries. In due course, on January 23, 2020, Malaysia's IHR Focal Point received an email from Singapore's IHR focal point regarding the need for contact tracing of the first COVID-19 case in Singapore. These led to Malaysia's

Abbreviations: ATFCOR, African Task Force for Coronavirus Preparedness and Response; COVID-19, Coronavirus Disease 2019; CPRC, Crisis Preparedness and Response Center; DOCE, Disaster, Outbreak, Crises, and Emergencies; EIS, Events Information Site; IHR, International Health Regulations; MOH, Ministry of Health; NADMA, National Disaster Management Agency; NGO, Non-Government Organization; NIH, National Institutes of Health; NSC, National Security Council; OSH, Occupational Safety and Health; PPE, Personal Protective Equipment; PUI, Patient Under Investigation; SARS-CoV, Severe Acute Respiratory Syndrome Coronavirus 2; USA, United States of America; WHO, World Health Organization.

first COVID-19 event, which was identified as one of the contacts from Singapore's case 2 days later, January 25, 2020. Effective communication between IHR focal points enabled early identification and quarantine to reduce Malaysia's disease spread. On the same day, the Malaysian IHR focal point notified the WHO of the first case of COVID-19 in Malaysia using IHR (2005) Annex 3. Malaysia is currently still reporting its cases weekly *via* the WHO website: https://COVID-19-dataentry-who.hub.arcgis.com.

Several national policies have been developed as guidelines in matters relating to crisis and security. One such guideline is Directive 20 of the National Security Council, which includes defined frameworks for the command, control, and coordination of health emergency preparedness and response. These frameworks are facilitated by the National Disaster Management Agency (NADMA) under the National Disaster Management Committee. This directive outlines the routes of response, roles, and obligations of each relevant agency, such that in the event of a health crisis, the MOH leads the technical direction. Several other laws and policy documents were also applicable to the response to COVID-19, including the Infectious Disease Prevention and Control Act (Act 342), the International Health Regulations, 2005 (IHR, 2005), and the MOH Disaster Management Plan (MOH, 2015).

The National Security Council (NSC), which works through committees at national, state, and district levels, manages the execution of overall policies involving multiple agencies. The national center for public health emergency operations supervised the planning, coordination, and implementation of response activities. It is known in Malaysia as the National Crisis Preparedness and Response Center (CPRC), MOH. The MOH provides technical advice through its disaster response committees, including the national CPRC (**Figure 1**). The national CPRC cascades the flow of command to propagate hospital services and primary care responses by central-level coordinators and is ultimately enforced at state and district levels.

WORKFORCE MOBILIZATION TEAM

The second wave of COVID-19 in Malaysia has precipitated the call for human resources reinforcements to support the District Health Offices' implementation of public health operations and containment measures. Contact tracing of the participants of the mass religious gathering was done actively by the district health teams, and the hardest-hit areas were the states of Selangor and Kuala Lumpur. Furthermore, the national CPRC, through its MOH COVID-19 Mobilization Support Unit, has prepared, organized, and enforced the deployment of human resources and medical countermeasures in the region. Simultaneously, with border control measures, the auxiliary workforce was also needed to screen travelers at international entry points, such as Kuala Lumpur International Airport. Hence, it was a requisite for MOH to strategize on the mobilization of healthcare workers and volunteers in affected areas where an additional workforce was required. The number of workforces, working hours, and each team's composition to be deployed was focused on the State Health Departments' needs and demands. The State Health Departments regularly tracked the progress of activities within each state.

A need assessment was carried out to determine the requirements of human resources during the pandemic. With the information obtained from field implementation activities and consideration of other factors, like the increasing number of cases, the national CPRC evaluated the gaps between existing conditions and the resources needed. These factors are summarized below.

Evaluation of Surge Capability

Exponential estimates of the number of cases and close contacts, increased R-naught, increased laboratory processing time, decreased data reporting timeliness, inadequate data quality, and overworked ground workers were indicators of an overwhelmed public health response system. The state health departments have identified limitations in human resources to the national CPRC, which has taken steps to overcome shortages.

Several factors also contributed to the rise in human resource requirements. For instance, the rapid increase of COVID-19 cases in the second wave created a massive patient burden, adding enormous strain to the current healthcare workers. In circumstances where healthcare workers had themselves contracted COVID-19, and their duties were suspended, the workforce shortages were exacerbated. All of them had to undergo COVID-19 testing and were quarantined for a fortnight. Furthermore, the Low-Risk COVID-19 Treatment and Quarantine Centers' opening scattered around Malaysia also required additional medical human resources.

Assessment of The Deployment Scope of Activities

Another relevant point considered in the healthcare personnel deployment was to assess the extent of the tasks to be carried out in maintaining the existing essential health services in MOH facilities and deal with increased workloads due to the handling of COVID-19 cases. The scope of the activities of healthcare personnel deployed are listed in the **Table 1**.

Priority is given for the MOH deployment, whereby personnel recruitment was made through communication between national and state CPRCs. Personnel involved in the mobilization of COVID-19 activities dependent on the tasks' feasibility and nature. The COVID-19 pandemic brought a response from all government agencies, for instance, the Ministry of Defense, the Ministry of Housing and Local Government, and the Ministry of Human Resources, enrolling masses of their staff to assist public health teams. The MOH has also obtained assistance from medical professionals and volunteers from the private and civil society (non-governmental organizations or NGOs) who have met the same recruitment requirements (7).

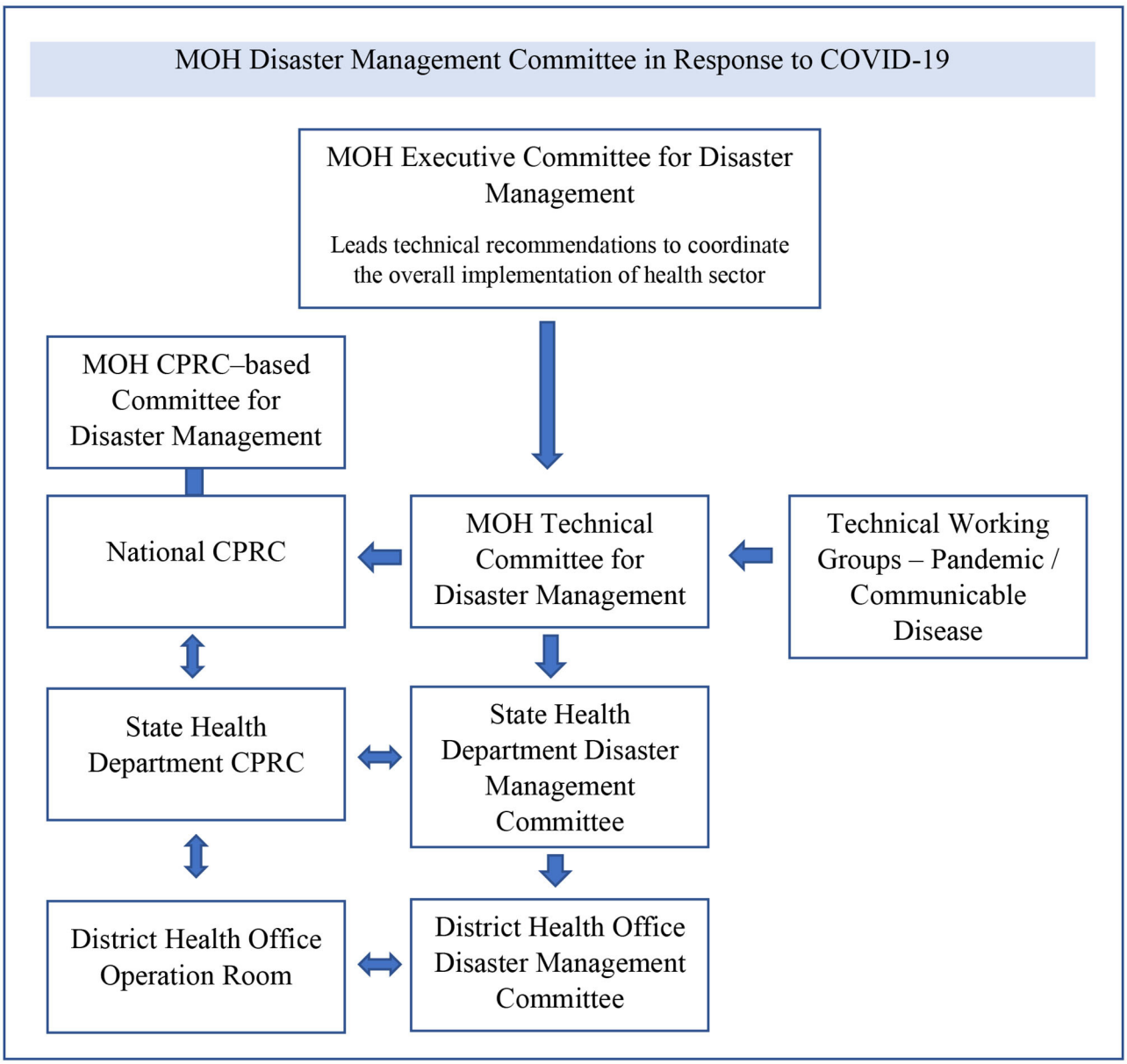

FIGURE 1 | MOH disaster management committee in response to COVID-19. (Source: MOH, MOH Disaster Response Plan, 2015).

NATIONAL INSTITUTES OF HEALTH COVID-19 OPERATION ROOM

The National Institutes of Health (NIH) COVID-19 operation room was established on March 17, 2020, following the activation of national CPRC and mandated by the Deputy Director-General of Health to help deal with the sudden surge of COVID-19 cases in Malaysia. The NIH is a unique healthcare organization under the MOH Malaysia consisting of six different institutes in a shared compound with a workforce of around 1,300 and various job positions from different medical/health backgrounds. The NIH is a tessellation of the Institute for Medical Research, Institute of Public Health, Institute for Health Management, Institute of Health System Research, Institute of Health Behavior Research, and Institute for Clinical Research. The NIH's core businesses include health-related research, conducting or organizing training and courses, and offering consultancy for the Ministry of Health personnel (8).

The NIH COVID-19 operation room serves as the center for communication and coordination of all activity relating to control and prevention of COVID-19 in NIH while harmonizing activity as well as the need from the national CPRC and State Health Departments. Besides anticipating requests from other healthcare facilities, the operation room is also responsible

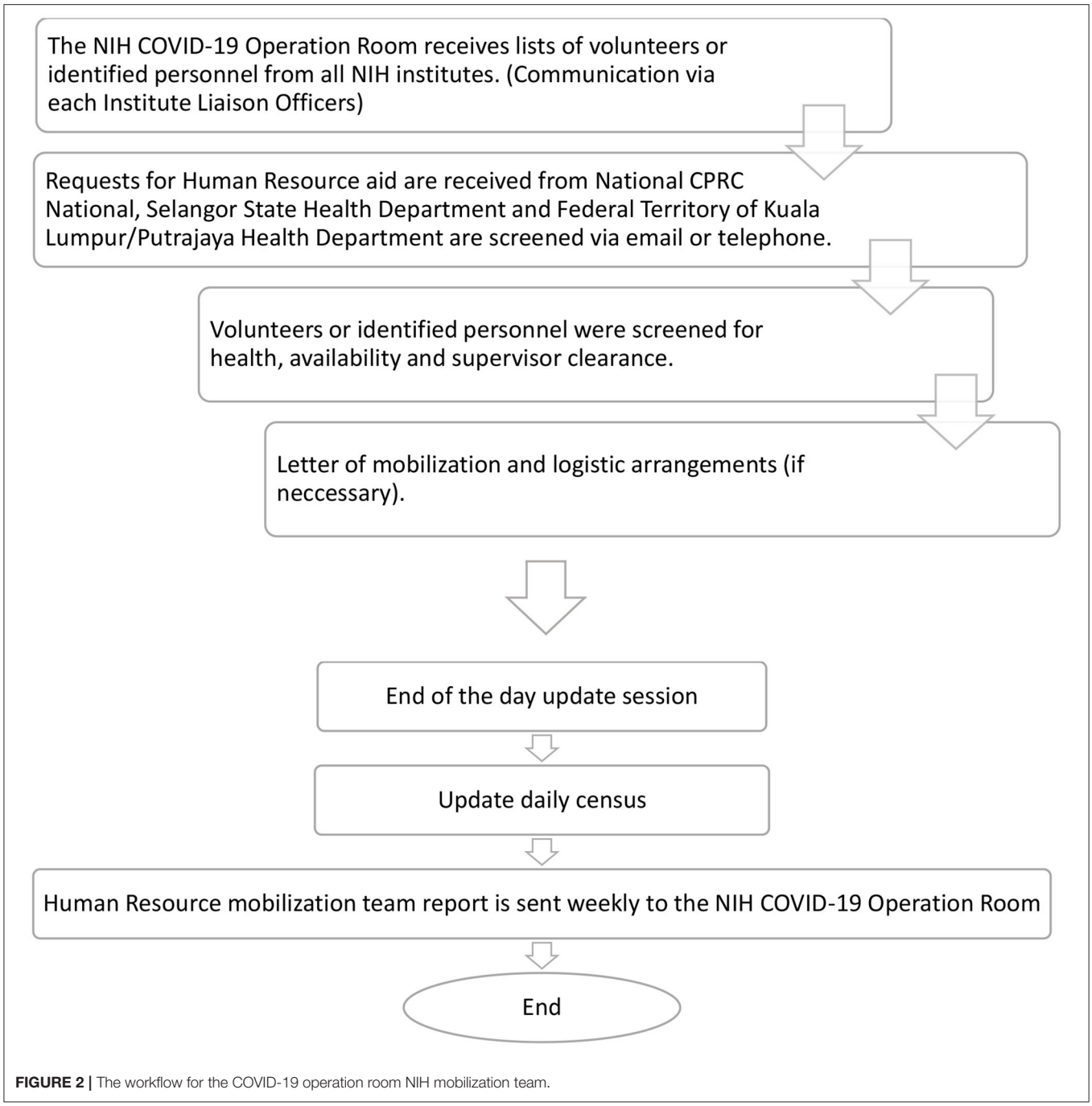

FIGURE 2 | The workflow for the COVID-19 operation room NIH mobilization team.

for the health surveillance of NIH personnel involved in the control and prevention of COVID-19 activity. Health promotion activities regarding COVID-19 for NIH personnel, including concession companies attached with NIH (e.g., cleaning services, security, catering), are coordinated by the NIH COVID-19 operation room.

As one of the NIH core businesses is research, all research activities relating to COVID-19, including diagnostic laboratory, are monitored by the NIH COVID-19 operation room. Other functions of the NIH COVID-19 operation room encompass the focal center for strategic cooperation between ministries and agencies in managing the spread of the COVID-19 pandemic and identifying and coordinating the need for accommodations for the workforce mobilization team.

In ensuring a smooth and effective mobilization system, a workforce mobilization team lead by the NIH COVID-19 operation room committee was formed with assistance from each institute's liaison officers under the NIH, which had been discerned beforehand. Liaison officers posited to identify personnel and prepare a list according to personnel readiness

for mobilization and location preferences. Since activation from March until June 2020, the NIH COVID-19 operation room have received human resource aid requests from the national CPRC, Selangor State Health Department, and Federal Territory of Kuala Lumpur/Putrajaya Health Department as early as 2 weeks before mobilization *via* email or telephone.

Subsequently, selected personnel need to be under 60 years of age, be registered as a licensed medical practitioner in Malaysia with the Malaysian Medical Council to conduct tasks involving contact with patients, and agree to sign a liability document. They would then be screened for health, availability, and clearance from the supervisor before a letter of mobilization can be issued and logistic arrangements made if necessary.

In the early phase of the COVID-19 pandemic, human resources in Malaysia's healthcare sectors focused on detecting and quarantine COVID-19 cases (8). Hence, other divisions that were not involved in early detection activities, including the NIH, offered human resource aid to other healthcare counterparts on the ground as frontliners. However, mobilized personnel from the NIH could be called back to work immediately upon their supervisors' request, together with substantial justification.

As the need for an extra workforce increased, more NIH personnel volunteered to assist. Teams were mobilized every week, but each cycle of deployment lasted 2 weeks. The number of personnel and composition of each deployment team was based on the requests of the national CPRC and State Health Departments. A pre-deployment briefing was given for each batch of groups, while further training was carried out at the assigned locations. Each briefing covered administrative matters, job scope, infection prevention, control, as well as accommodation etiquette. The workflow of facilitating mobilization is visualized in **Figure 2**.

TABLE 1 | Scope of activities for the healthcare personnel during deployment.

No.	Scope of activities
1	Identifying of active cases
2	Assisting the monitoring of PUI home surveillance
3	Health monitoring of the organization employees
4	Issuing Quarantine Order Forms
5	Distributing PPE
6	Providing a service for psychosocial assistance
7	Swab sampling of symptomatic and asymptomatic patients
8	Managing data
9	Providing orientation and training sessions for volunteers
10	Assisting frontliners in the care of patients
11	Carrying out interviews with contract-for-service staff
12	Hotline call duties
13	Chest X-ray / Laboratory testing
14	Producing PPE and preparation that includes aprons, face mask, headgear, boot cover, etc.
15	COVID-19-related research
16	Transporting COVID-19 PUI and supporting patients to the respective health facilities
17	Determining health workers for mobilization
18	Supervising sites and providing input on any inquiries made by volunteers
19	Assisting at the State and District Health Operations Centers
20	Contact tracing of the PUI from various sources and notifications
21	Determining the need for and organizing mobilization team accommodation
22	Preserving current essential healthcare services
23	Supplying first aid and medical care to volunteers (when necessary)
24	Individual and mass screening
25	Aiding public inquiries related to COVID-19
26	Managing the deceased in cases of COVID-19

DETAILS TO UNDERSTAND KEY PROGRAMMATIC ELEMENTS

The first deployment began with eleven personnel to the national CPRC and Sungai Buloh Hospital (the main COVID-19 treating hospital) on March 17, 2020. Later, on March 29, 2020, the number quadrupled to 47 mobilized personnel to the national CPRC, Selangor State Health Department, three district health offices in Selangor, and Sungai Buloh Hospital. Throughout the establishment of the NIH COVID-19 operation room, it is estimated about 128 personnel were cumulatively mobilized from every institute under the roof of NIH to ease the burden on another healthcare workforce due to the COVID-19 pandemic. All six institutes actively provided human resource aid to the MOH facilities around the Federal Territory of Kuala Lumpur & Putrajaya and the largest state by population, Selangor. Considering those who volunteered and those who were assigned for attachment for career advancement, **Table 2** shows the location and the total number of personnel mobilized from the NIH.

TABLE 2 | Location and the total number of mobilized personnel from the National Institutes of Health Malaysia.

No.	Location	Total mobilized
1	National Crisis Preparedness and Response Center (CPRC), Ministry of Health	44
2	Selangor State Health Department	14
3	Federal Territory of Kuala Lumpur & Putrajaya Health Department	14
4	Petaling District Health Office	20
5	Gombak District Health Office	6
6	Hulu Langat District Health Office	8
7	Sepang District Health Office	6
8	International Entry Points, Kuala Lumpur International Airport (KLIA)	4
9	Kuala Lumpur General Hospital	5
10	Sungai Buloh Hospital	7
Total		**128**

The human resource mobilization team received involvement from every job position level, which depicted a high level of teamwork and a sense of responsibility within the MOH during this challenging period. Public health physicians, medical officers, dental officers, environmental health officers, and nurses have valuable skills and clinical expertise that can be

TABLE 3 | Number of mobilized personnel by job positions.

No.	Job position	Total mobilized
1	Public Health Physicians	6
2	Medical Officer	60
3	Research Officer	21
4	Dental Officer	1
5	Health Education Officer	4
6	Science Officer	5
7	Environmental Health Officer	1
8	Nurse	4
9	Pharmacy	6
10	Statistician	4
11	Assistant Research Officer	1
12	Assistant Statistician	2
13	Assistant Environmental Health Officer	1
14	Administrative Assistant	9
15	Assistant Librarian	3
Total		**128**

appropriately used to assist frontliners. Public health physicians and environmental health officers are also the most competent to conduct public health measures under the Prevention and Control of Infectious Disease Act 1988 (Act 342), such as issuing a quarantine order. Other job positions were determined later on, according to where this group of different backgrounds and skilled personnel could be best stationed. The breakdown of personnel mobilization by job position is shown in **Table 3**.

As the human resource aid that we provided began to relieve the pressure and load from the assigned locations, other job positions were sent for non-clinical support. The non-clinical support mainly evolves around data management as data received daily could be overwhelming for small operation centers like the district offices. After the first month of personnel mobilization, most clinical personnel have returned to their respective institutes to continue the existing tasks. The movement of the entire NIH personnel was put into a master list using Microsoft Excel. As a result, a live database of mobilized workforces was created and accessible to all NIH personnel for monitoring as well as record keeping. This database was also being used as health surveillance and staff attendance, which are salient in emergencies.

DISCUSSION

The national CPRC was established in January 2020 by the Ministry of Health Malaysia and triggered activation of CPRC and COVID-19 operation room at other healthcare facilities around the country, abiding by the Event-based Surveillance Protocol in addressing the public health emergency of international concern (9–11). The human resource mobilization division for the national CPRC was founded on March 11, 2020. Their first deployment team comprised 60 personnel from seven State Health Departments to the Selangor state health department and the Federal Territory of Kuala Lumpur health department. This human resource mobilization team's underlying motivation and aim were to efficiently mobilize the healthcare workforce as a COVID-19 response in a strategic, safe, astute, and resource-conscious way.

Our response team's efforts in identifying evolving needs and promptly engaging relevant workforces within the MOH had countless advantages. Many non-clinical workforces were keen to combat the deadly pandemic but felt powerless. However, research has shown that united action toward a common goal can parry these emotions (12). Together with enthusiasm toward such a desire, orderly measures can foster a sense of empowerment, motivation, and connection. An effective disease control strategy demands an efficient public health workforce, sophisticated integrated public health and clinical health information technology, trained human resources, and substantial community involvement (4, 12).

A similar response observed in South Africa, where the Africa Centers for Disease Control and Prevention has initiated an African Task Force for Coronavirus Preparedness and Response (ATFCOR) focusing on six workstreams: laboratory diagnosis and subtyping; surveillance (including screening at points of entry and cross-border activities); infection prevention and control in healthcare facilities; clinical treatment and management of people with severe COVID-19; risk communication; as well as supply chain management and stockpiles (13).

The effectiveness of an organization's human resources management and its team development is a significant factor that affects that organization (14). The human resource mobilization team in the NIH COVID-19 operation room act as a coordinator for personnel deployment from NIH and require inter-organization commitment as well as necessitate full responsibility from the liaison officers for an effective system. All six NIH institutes had their respective organization and sub-organization that potentially delayed the process of verifying personnel for mobilization. The situation was exacerbated when requests were received for human resource aid at the latest possible time resulting in engendering personnel to prepare for mobilization inadequately. Regardless, the mobilized team was briefed to equip them mentally and physically, albeit tasks were given by assigned medical facilities independently. There is precedent for such an enormous mobilization to address a pandemic. In reducing the spread of Ebola, African countries mobilized thousands of caseworkers while China reportedly mobilized 18,000 public health workforces to curb the spreading of COVID-19 in Wuhan alone (15).

To help in response to COVID-19, other countries, such as the USA and Croatia, mobilized their medical students to do anything from providing childcare to healthcare workers to enrolling in short-term roles in the healthcare system (13–15). Malaysia utilizes a different approach whereby, instead of recruiting medical students, we encourage volunteers from retirees with a medical background. We also received volunteers from other ministries such as the Ministry of Housing and Local Government and Malaysian Armed Forces; non-government organizations (NGO) like Medical Relief Society Malaysia,

Malaysia Relief Agency, and Islamic Medical Association of Malaysia Response & Relief Team; as well as government agencies, for example, the Department of Occupational Safety and Health Malaysia. These collaborations with NGOs and other agencies, resulting in a seamless distribution of the workforce, food supplies, and personal protective equipment (PPE) all around Malaysia. Moreover, the collaborations provide an opportunity for medical personnel outside of the MOH to contribute and serve the country.

As a result of lessons learned during the SARS and influenza pandemic, the development and standardization of plans, including human resource mobilization, operational support, space, and equipment, are vital in the first few hours of an outbreak. Deployment and mobilization should be assessed early and frequently during the response to enhance the preparedness of pre-identified workforces (16). The AsiaFluCap Project (2008–2011), which was based in Germany, analyzed the feasibility and capability of health system resources mobilization across selected Asian countries in the event of an influenza pandemic. Using a mathematical transmission model, they could estimate gaps in healthcare resources vital for responding to the influenza pandemic by simulating a mild to moderate scenario of an influenza pandemic (17). Lesson learnt from that exercise, suggesting that a pandemic could have a high public health impact with the maldistribution of resources.

Our mobilized team received recognition nationally for their contribution to the country. Apart from offering a helping hand to the overwhelming workload, we have also developed new methods to manage the COVID-19 pandemic, which were adapted by the MOH Malaysia. For instance, an electronic form was created for a comprehensive data collection on contact tracing. The template has been used in several states in Malaysia along with a density map that inspires modeling with a projection of COVID-19 virus spread based on daily cases and reproduction number (18, 19).

Nevertheless, the human resource mobilization team faced a few challenges in the course of its operation. Receiving an overwhelming amount of volunteers since the inception of the NIH COVID-19 operation room, the process of screening these volunteers was time-consuming and calling up identified volunteers labor-intensive. The lack of a medical volunteer registry to recruit personnel slowed the process of deployment in the beginning. There were also several challenges with regards to the deployed healthcare personnel's skills and competencies. Throughout the early phases of the pandemic and with COVID-19 being a new disease, healthcare personnel may not have been entirely aware of or familiar with the clinical recommendations for the treatment of COVID-19.

Moreover, the personnel themselves were at constant risk of exposure to the virus. This risk is exacerbated by the threat of psychological consequences such as anxiety and depression due to stigma. It was essential to track the well-being of all deployed personnel through a system of continuous guidance and close supervision as well as monitoring by the occupational health and safety teams within healthcare facilities. Well-established mental health and psychosocial support platforms were also crucial in ensuring the continued morale and desire of deployed personnel to fulfill their duties.

Another realization that arose during the pandemic is related to all deployed personnel's readiness to work in a crisis setting. The COVID-19 challenged the healthcare system to such an extent that all staff, from technical to support and clinical to non-clinical, were entailed in some way in the country response, thus coining terms such as "frontliners" and "backliners." Many deployed personnel had steep learning curves to quickly familiarize themselves with the given tasks that were very different from the routine day-to-day work and in a full of urgency environment. Tasks have been carried out with involvement from all organizations, both governmental and non-governmental, depicting an all-out approach from a large team. Therefore, all personnel need to have some sort of readiness training in a public health emergency setting, and these preparations should be not only physical but also mental. The ability to predict potential challenges to healthcare personnel during a pandemic crisis would add value in ensuring more effective and productive management for future crises.

One of the workforce mobilization teams' unforeseen challenges was the growing numbers of infected healthcare personnel, which has resulted in a shortage of personnel in some hospitals. Human resources for health became scarce, and considerations were required to ensure healthcare quality and delivery uninterrupted. As a result, a range of measures has been outlined to ensure the continuation of health services. First of all, priority was given to emergency departments and hospital wards regarding the distribution of resources. Mobilization of healthcare personnel from other facilities, either interstate or intrastate, and personnel rotation between departments were among the measures taken. In certain situations, the Occupational Safety and Health (OSH) Units of the health facilities ordered the temporary closure of those departments that have had a few healthcare personnel with positive COVID-19. The whole department was disinfected and sanitized before the resumption of operations (7).

As a proactive response, the MOH introduced and implemented various ground-breaking concepts, such as teleconsultations, drive-thru pharmacies, and notifications of waiting numbers *via* messages or WhatsApp®. These improvisations helped to minimize the need for healthcare personnel to be physically present and indirectly limit the interaction and exposure between the healthcare personnel and patients. In the event of severe staff shortages, the OSH officer will assess the healthcare personnel to decide the appropriateness for an early return to work.

The NIH COVID-19 operation room recognized there are some possible limitations from the workforce mobilization activity. Firstly, mobilizations were based on request and availability at a particular moment. Hence, the assessment of support needed and given may not necessarily reflect the operation's actual requirements. Indeed, the whole experience has been a lesson in teamwork and coordination. The different strengths of the respective personnel in the various teams have harmoniously complemented each other by creating

a diverse group that has responded potently against this pandemic situation.

This article also focuses on the workforce mobilization from the NIH to the other public healthcare facilities within the MOH Malaysia in the early phases of the COVID-19 pandemic management in Malaysia. The requests that we received only come from the central region. The Crisis Preparedness and Response Center, MOH Malaysia, based in the Federal Territory of Putrajaya, coordinates workforce mobilization involving interstates and other healthcare facilities. However, the lack of information, especially on average working hours of the volunteers and the work shift system implemented at individual locations, impede estimating the optimal number of personnel to be mobilized. Instead, the workforce mobilization is varying and is subjectively tailored to the request from the locations mentioned earlier. These variables are valuable to improve the efficiency of mobilization in the future.

CONCLUSION

Mobilization of human resources within the MOH was a critical technique to maximize human resource capacity during a pandemic. Developing a database of volunteers ready for future deployment in a disaster or crisis may become crucial in human resource mobilization management. The next step should be establishing an online volunteer management system that would integrate the current database and allow for more rapid deployment. Such a centralized system would ease the recruitment process in terms of accurately identifying the available expertise and locating suitable experts to be deployed to selected regions. A carefully established data management and relevant information availability might be the key to answering some of the challenges faced during pandemic management in the future, including COVID-19.

The NIH COVID-19 operation room was effectively closed on June 15, 2020, succeeding the Deputy Director-General of Health's approval after observing improved infected COVID-19 cases throughout the country. Nonetheless, the war against the COVID-19 pandemic demands an efficient workforce and effective response team that can rise to the challenge for a safer and healthier world.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

AM was the Head of the Workforce Mobilization committee for NIH COVID-19 Operation Room. The NIH COVID-19 Operation Room was led by NIB as the commander and assisted by YC as the deputy commander. The operation room would not be successful without AB as the coordinator and supervised the NIH personnel movement database. AM, YL, AB, and NIB contributed tremendously to the production of this manuscript. NHB reviewed and gave technical advisory toward the manuscript as well as contributed essential revisions. All authors read and approved the manuscript.

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REFERENCES

1. Worldometer. Coronavirus Cases. Worldometer (2020). Available online at: https://www.worldometers.info/coronavirus/coronavirus-cases/#daily-cases (accessed May 29, 2020)
2. Coronavirus (COVID-19) events as they happen. Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/events-as-they-happen (accessed May 29, 2020).
3. Home COVID-19 MALAYSIA. Available online at: http://covid-19.moh.gov.my/ (accessed June 10, 2020).
4. Lodha R, Kabra SK. COVID-19: how to prepare for the pandemic? *Indian J Pediatr.* (2020) 13:1–4. doi: 10.1007/s12098-020-03293-0
5. Levin PJ, Gebbie EN, Qureshi K. Can the healthcare system meet the challenge of pandemic flu? Planning, ethical, and workforce considerations. *Public Health Rep.* (2007) 122:573–8. doi: 10.1177/003335490712200503
6. Mat N, Edinur H, MR-J of T. A single mass gathering resulted in massive transmission of COVID-19 infections in Malaysia with further international spread. *J Travel Med.* (2020) 27:taaa059. doi: 10.1093/jtm/taaa059
7. Institute for Health Systems Research. *Malaysia Health Sector Response to COVID-19 Pandemic*. Selangor MYS: Institute for Health Systems Research (IHSR), Ministry of Health Malaysia (2020).
8. National Institutes of Health Malaysia. Available online at: http://nih.gov.my/ (accessed September 21, 2020).
9. Soled D, Goel S, Barry D, Erfani P, NJ-A. Medical student mobilization during a crisis: lessons from a COVID-19 medical student response team. *Acad Med.* (2020) 95:1384–7. doi: 10.1097/ACM.0000000000003401
10. Lancet MM-T, 2020. Africa prepares for coronavirus. *Lancet.* (2020) 395:483. doi: 10.1016/S0140-6736(20)30355-X
11. Ministry of Health Malaysia, D. *Event-based surveillance protocol.* (2018). Retrieved from: https://www2.moh.gov.my/moh/resources/Penerbitan/Garis%20Panduan/Garis%20panduan%20Umum%20(Awam)/Buku_Event-Based_Surveillance.pdf
12. Eisenstein L. To fight burnout, organize. *N Engl J Med.* (2018) 379:509–11. doi: 10.1056/NEJMp1803771
13. Ellis R, Hay-David AGC, Brennan PA. Operating during the COVID-19 pandemic: how to reduce medical error. *Br J Oral Maxillofac Surg.* (2020) 58:577–80. doi: 10.1016/j.bjoms.2020.04.002

14. Yildirim N, Korkmaz Y. Challenge of millennials in project management. *Int J Inf Technol Proj Manag.* (2017) 8:87–108. doi: 10.4018/IJITPM.20170 40106
15. Bauchner H, Sharfstein J. A Bold Response to the COVID-19 Pandemic. *JAMA.* (2020) 323:1790–1. doi: 10.1001/jama.2020.6166
16. Peitl V, Karlović D. Mental health issues and psychological crisis interventions during the COVID-19 pandemic and earthquakes in croatia. *Arch Psychiatry Res.* (2020) 56:8. doi: 10.20471/dec.2020.56.02.07
17. Posid J, Bruce S, Guarnizo JT. SARS: mobilizing and maintaining a public health emergency response. *J Public Health Manag Pract.* (2005) 11:208–15. doi: 10.1097/00124784-200505000-00005
18. Ahmad A, Krumkamp R, Hanvoravongchai P, Coker R, Reintjes R. *The AsiaFluCap Project: Evaluation Report*.
19. Kenyataan Akhbar KPK 1st June 2020 – Situasi Semasa Jangkitan Penyakit Coronavirus 2019 (COVID-19) di Malaysia – From the Desk of the Director-General of Health Malaysia. Available online at: https://kpkesihatan.com/2020/06/01/kenyataan-akhbar-kpk-1-jun-2020-situasi-semasa-jangkitan-penyakit-coronavirus-2019-covid-19-di-malaysia/ (accessed June 10, 2020).

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How Well the Government of Nepal Is Responding to COVID-19? An Experience From a Resource-Limited Country to Confront Unprecedented Pandemic

*Binod Rayamajhee[1,2], Anil Pokhrel[3], Gopiram Syangtan[4], Saroj Khadka[3], Bhupendra Lama[3], Lal Bahadur Rawal[5], Suresh Mehata[6], Shyam Kumar Mishra[1,7], Roshan Pokhrel[6] and Uday Narayan Yadav[8,9,10]**

[1] School of Optometry and Vision Science, University of New South Wales, Sydney, NSW, Australia, [2] Department of Infection and Immunology, Kathmandu Research Institute for Biological Sciences, Kathmandu, Nepal, [3] Central Department of Microbiology, Tribhuvan University, Kathmandu, Nepal, [4] Shi-Gan International College of Science and Technology, Tribhuvan University, Kathmandu, Nepal, [5] School of Health Medical and Social Sciences, Central Queensland University, Sydney, NSW, Australia, [6] Ministry of Health and Population (MoHP), Government of Nepal (GoN), Kathmandu, Nepal, [7] Department of Microbiology, Institute of Medicine, Tribhuvan University, Kathmandu, Nepal, [8] Centre for Primary Health Care and Equity, University of New South Wales, Sydney, NSW, Australia, [9] Centre for Research, Policy and Implementation, Kathmandu, Nepal, [10] Torrens University, Sydney, NSW, Australia

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***Correspondence:**
Uday Narayan Yadav
unyadav1@gmail.com

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COVID-19, caused by SARS-CoV-2, was first reported in Wuhan, China and is now a pandemic affecting over 218 countries and territories around the world. Nepal has been severely affected by it, with an increasing number of confirmed cases and casualties in recent days, even after 8 months of the first case detected in China. As of 26 November 2020, there were over 227,600 confirmed cases of COVID in Nepal with 209,435 recovered cases and 1,412 deaths. This study aimed to compile public data available from the Ministry of Health and Population (MoHP), Government of Nepal (GoN) and analyse the data of 104 deceased COVID-19 patients using IBM SPSS (Version 25.0). Additionally, this study also aimed to provide critical insights on response of the GoN to COVID-19 and way forward to confront unprecedented pandemic. Figures and maps were created using the Origin Lab (Version 2018) and QGIS (Version 3.10.8). Most of the reported cases were from Bagmati Province, the location of Nepal's capital city, Kathmandu. Among deceased cases, >69% of the patients were male and patients ≥54 years accounted for 67.9% (n = 923). Preliminary findings showed respiratory illness, diabetes, and chronic kidney diseases were the most common comorbid conditions associated with COVID-19 deaths in Nepal. Despite some efforts in the 8 months since the first case was detected, the government's response so far has been insufficient. Since the government eased the lockdown in July 2020, Nepal is facing a flood of COVID-19 cases. If no aggressive actions are taken, the epidemic is likely to result in significant morbidity and mortality in Nepal. The best way to curb the effect of the

ongoing pandemic in a resource-limited country like Nepal is to increase testing, tracing, and isolation capacity, and to set up quality quarantine centers throughout the nation. A comprehensive health literacy campaign, quality care of older adults and those with comorbidity will also result in the effective management of the ongoing pandemic.

Keywords: covid-19 pandemic, health care delivery, leadership and management, non-communicable diseases, policies and strategies, quarantine management, vaccination

OVERVIEW OF THE GLOBAL IMPACT OF COVID-19

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), which causes the coronavirus disease (COVID-19), was first identified in Wuhan, China, in December 2019 and later spread globally (1). The World Health Organization (WHO) declared the outbreak a Public Health Emergency of International Concern (PHEIC) on 30 January (2) and a pandemic on 11 March 2020 (3). COVID-19 has now affected over 218 countries and territories around the world, as well as two international conveyances (4). As of 26 November 2020, there have been 61,126,600 COVID-19 cases confirmed globally, with 1,433,866 (2.35%) deaths and 42,292,160 (69.19%) recovered cases (4). The highest number of deaths have been reported in the USA (13,197,307), followed by India (9,308,751) and Brazil (6,170,827) (4). The South Asian Association of Regional Cooperation (SAARC), a regional inter-government consortium of eight South Asian countries, which includes Nepal, India, Bangladesh, Pakistan, Maldives, Bhutan, Sri Lanka, and Afghanistan, comprises over 21% of the global population and is vulnerable to COVID due to multiple factors including poor health literacy, poor housing and living conditions, fragile health systems coupled with inadequately trained frontline health workers, poor quality of health care coupled with the poor diagnostic capacity of laboratory facilities and population of poor and migrant individuals (5, 6). As of 26 November 2020, Nepal holds the fourth position among the SAARC member countries in terms of total COVID infections and death cases, with India placing first and Bhutan placing last (**Figure 1**) (5).

SITUATION OF COVID-19 IN NEPAL

Nepal adopted a federal democratic structure in 2017 and currently has seven provinces: Province No. 1, Province No. 2, Bagmati Province, Gandaki Province, Lumbini Province, Sudurpaschim Province and Karnali Province. Of the provinces, Bagmati Province currently has the highest number of COVID-19 cases and has reported the highest number of deaths (48.87%, $n = 690$). Out of 77 districts, the Kathmandu district reported the highest number of mortalities (24.00%, $n = 339$), followed by Lalitpur (6.8%, $n = 96$), Bhaktapur (6.30%, $n = 89$), and Sunsari (5.02%, $n = 71$) (**Figure 2**).

The first positive case of SARS-CoV-2 in Nepal was reported in a Nepalese national who had returned to Kathmandu from Wuhan, China on 23 January 2020 (7). For several weeks after the first case which was reported in the last week of January 2020, Nepal did not witness an increasing number of COVID cases. However, since July and August 2020, Nepal experienced an unexpected surge of cases every day. As of 26 November 2020; 1,700,000 reverse transcription polymerase chain reaction (RT-PCR) tests have been performed in seven provinces, of which 227,640 have tested positive for SARS-CoV-2 (**Figure 3**).

Of the total positive cases, 209,435 have recovered, and 1,412 deaths have been confirmed. A total of 16,793 cases are active and under isolated surveillance, with more than 600 suspected cases currently in quarantine (8). As of 24 November 2020, deceased patients who were older than 54 years accounted for 67.82% ($n = 923$), while those aged 25–54 years accounted for 28.36% ($n = 386$), and of total deceased patients 69.43% ($n = 945$) were male (**Figure 4**). Patients older than 85 years have the highest case fatality rate (CFR) of 8.5% as of 24 November 2020 (9).

The first death reported in Nepal was a 29-year-old pregnant woman. One deceased patient was an organ recipient, and three had a history of surgery. As of 16 August 2020, the Government of Nepal (GoN) has issued data of the underlying infections in deceased COVID-19 patients but later the GoN stopped to release the data on the underlying illness due to spiked cases of COVID-19 deaths. We have reported the available data of till mid-August to highlight the underlying illness among deceased COVID-19 patients in Nepal. The most common underlying conditions among the 104 deceased patients were respiratory illness (including asthma, pneumonia and other non-specified, 53.85%, $n = 56$), diabetes (21.2%, $n = 22$), chronic kidney disease (14.4%, $n = 15$), and hypertension (13.5%, $n = 14$) (**Figure 5**). Thirty-eight of the deceased patients had suffered from two or more comorbidities. Six patients died either in self-isolation or before they were able to reach a hospital and, therefore, other underlying illness could not be assessed.

As of 24 November, among all deceased patients, 895 (65.76%) patients had at least one pre-existing condition of comorbidity and such comorbidity was recorded apparently higher in older patients, highest comorbidity (26.82%, $n = 240$) being recorded in the age group 65–74 years (9).

As the number of RT-PCR tests has increased (**Figure 6**), Nepal has witnessed increasing numbers of COVID cases, but the number of cases requiring specialized care such as intensive care units or life support with ventilators is also increasing every day (10). Several factors may have influenced the increased number of COVID cases in the country. First, the outbreak may be spiraling upward due to the cohabitation practices of the joint family system in Nepal, which is similar to Northern Italy (11). The southern plain region of Nepal-Terai, which has an open border with the northern part of India, a country that occupies the third

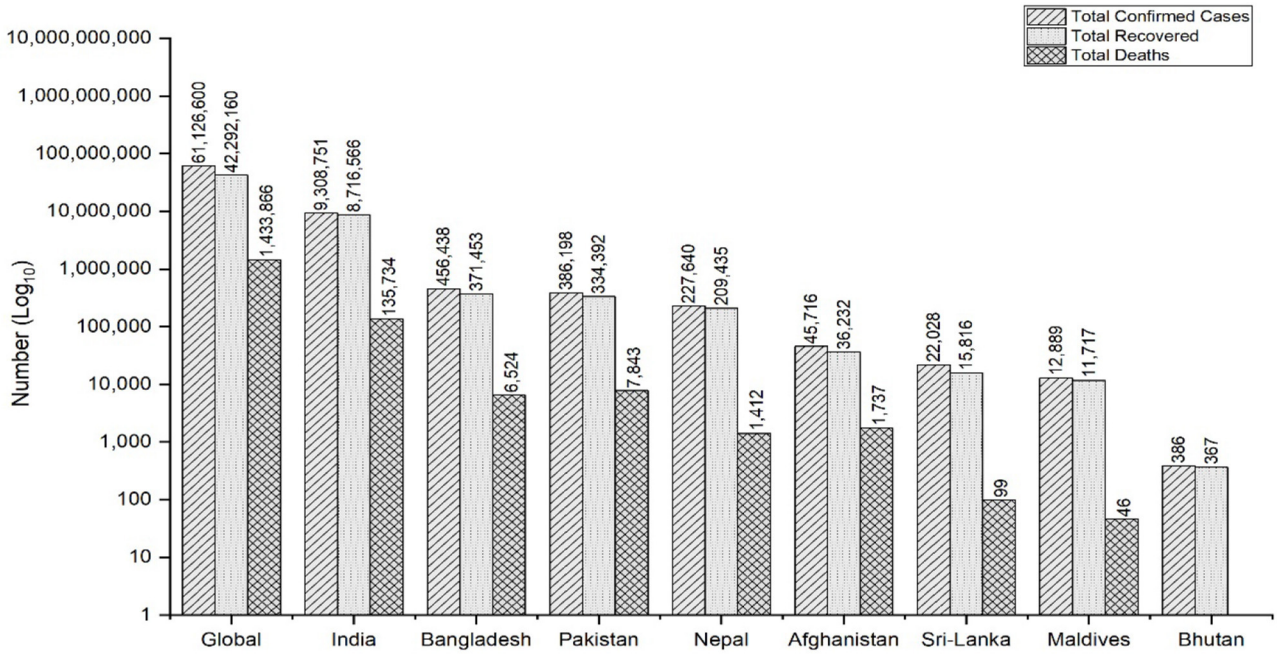

FIGURE 1 | COVID-19 cases in SAARC member states.

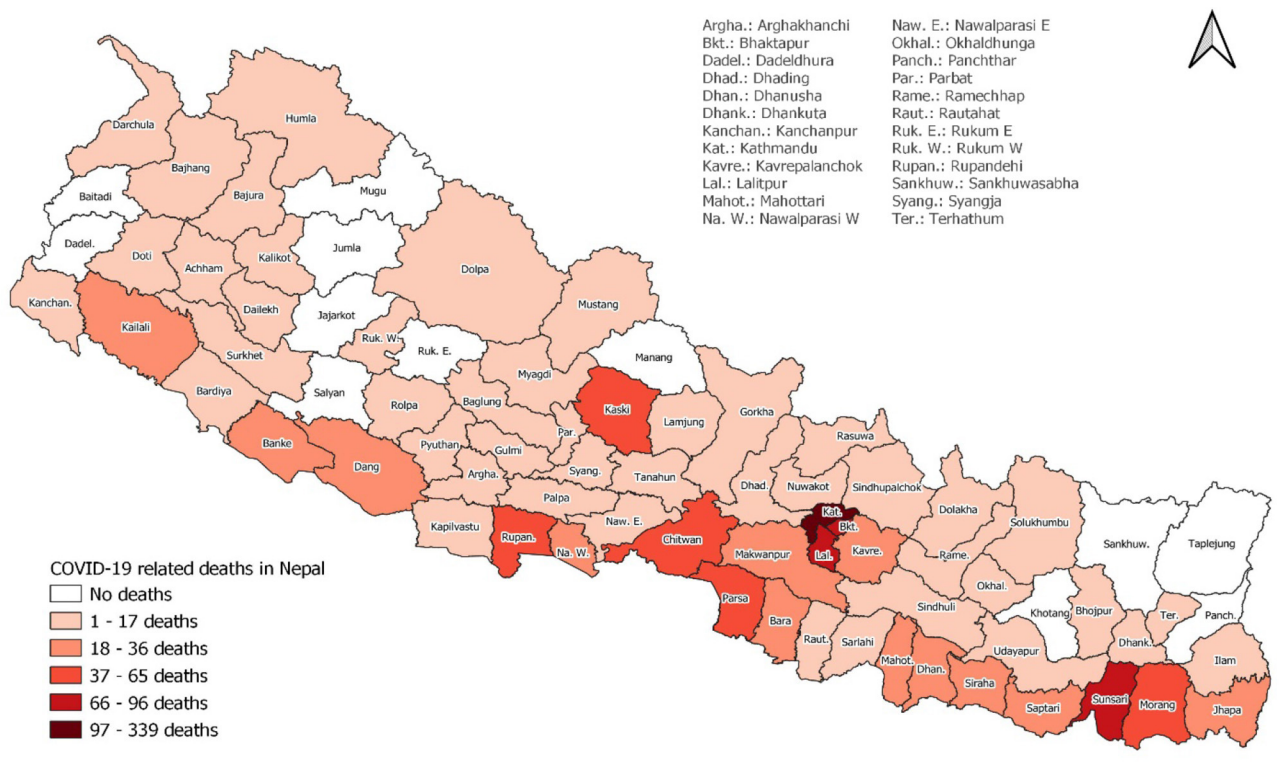

FIGURE 2 | District-wise death cases of Covid-19 in Nepal.

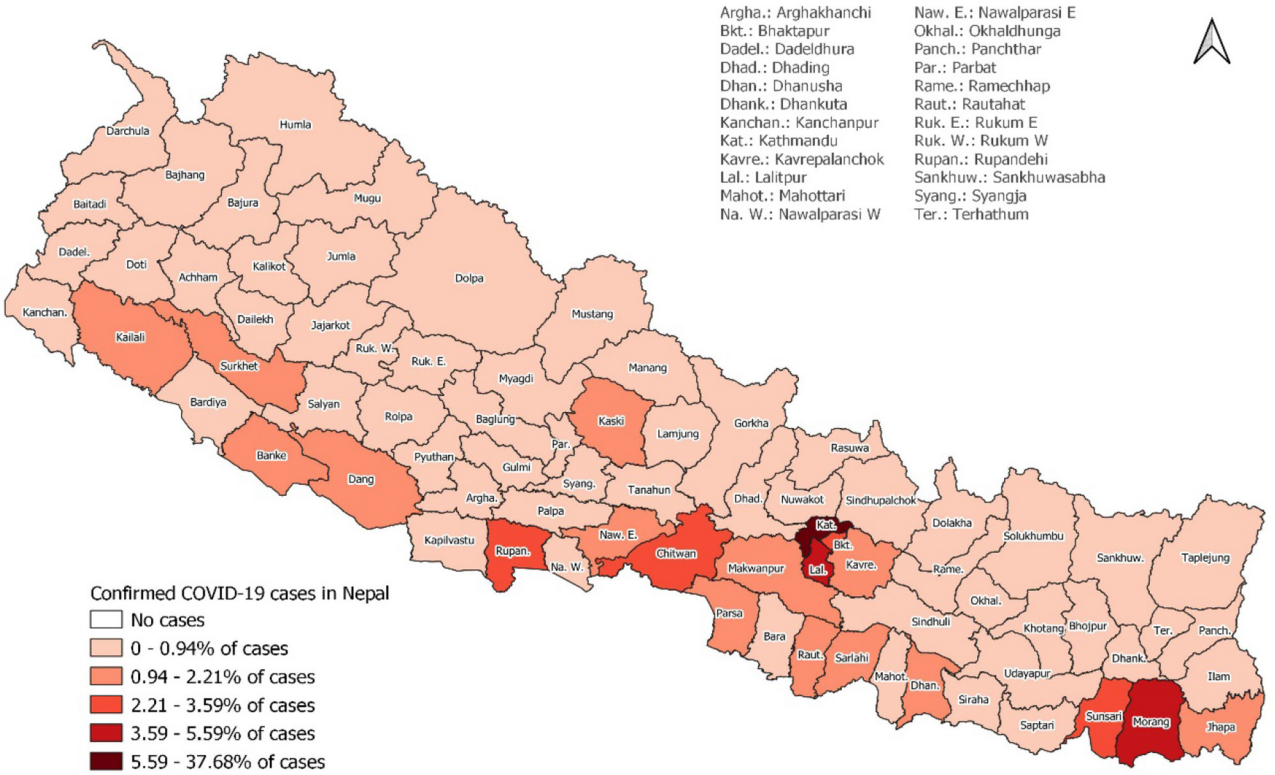

FIGURE 3 | Cumulative cases of COVID-19 cases in different districts of Nepal.

position in terms of global COVID cases, has also been a hotspot; this area is the source of an influx of Nepalese migrants, which may have contributed to a higher number of COVID cases in this region. Despite continuous efforts, the Nepalese authorities have so far failed to systematically and effectively quarantine citizens returning from other countries, especially from India. Despite these facts, it is significant that most deceased patients had no travel history, and this suggests local community transmission of the disease.

PRE-EXISTING CONDITIONS AND COVID-19

The preliminary analyses of data (16 August 2020) on underlying illness in deceased COVID-19 patients of Nepal showed nearly 87% of patients had pre-existing conditions i.e., non-communicable diseases (NCDs). The evidence shows that people living with NCDs are more vulnerable to severe illness or death as a result of infection with COVID-19 (12, 13). In Italy, among those COVID patients who died in hospitals, 68% had hypertension, and 31% had type-2 diabetes. In India, 30% fewer acute cardiac emergencies reached health facilities in rural areas in March 2020 compared to the previous year. In the Netherlands, the number of people newly diagnosed with cancer dropped by 25% as a result of lockdown measures imposed by the government. In Spain, among patients with severe symptoms, 43% had existing cardiovascular diseases (12). Bhatraju et al. (14) reported that majority of the COVID cases in the US had comorbid conditions, particularly NCDs such as diabetes (58%), kidney dysfunction (21%), asthma (14%), and chronic obstructive pulmonary disease (COPD) (4%). The same study reported that 33% of patients had more than one coexisting condition (14). Guan et al. recorded hypertension in 16.9%, diabetes in 8.2%, hepatitis B infection in 1.8%, chronic kidney disease in 1.3%, malignancy in 1.1%, and immunodeficiency in 0.2% of COVID patients in China (15). They also reported two or more comorbid conditions in 8.2% of patients with SARS-CoV-2 infection. These multi-morbid conditions were observed more commonly in COVID cases with severe conditions than in cases with mild or no symptoms (14, 16). We found a greater number of comorbidities correlated with greater disease severity in Nepalese COVID patients. The overall case fatality ratio (CFR) across all ages in Nepal has remained $<1\%$ (8, 17).

The world has witnessed discrepancies in the burden of COVID cases and the challenges of managing cases effectively and efficiently. Such discrepancies cannot be explained solely by current patterns of population age groups in countries like Nepal, where health care facilities have been heavily disrupted by the ongoing pandemic (11, 18, 19). The severity and mortality rate of COVID-19 has been increased by

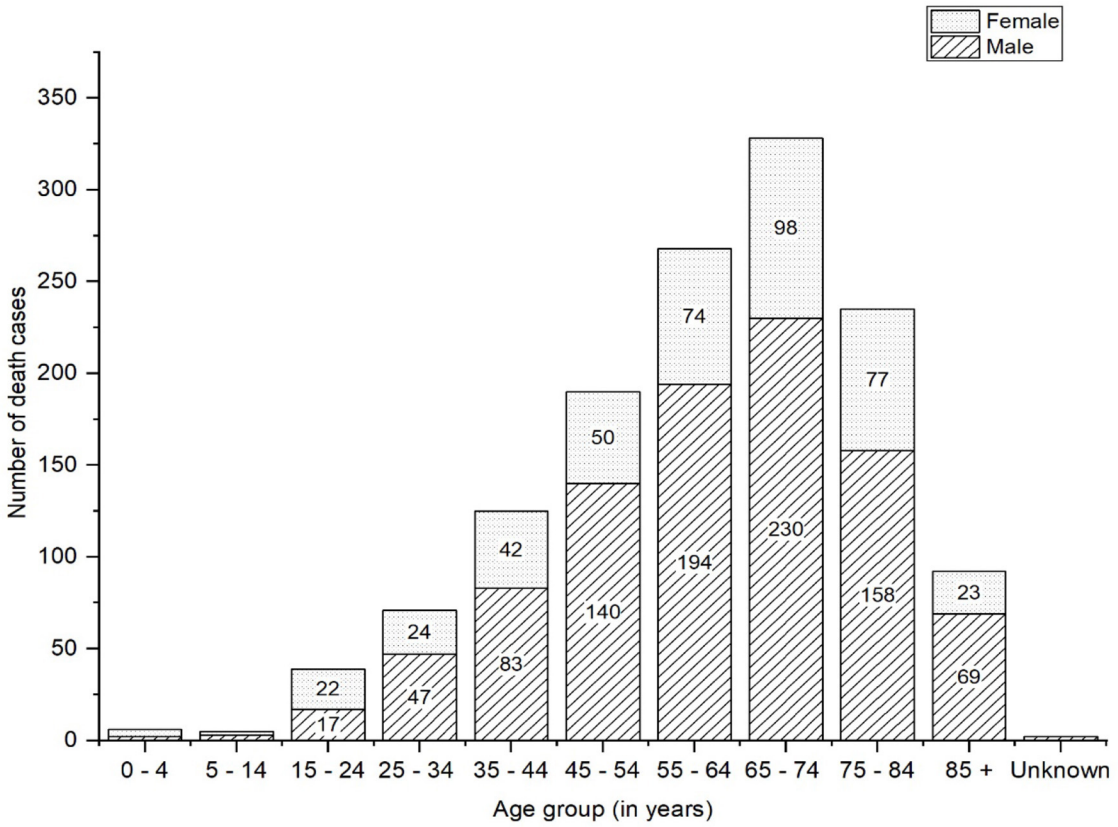

FIGURE 4 | Age wise distribution of deceased COVID-19 patients.

the presence of underlying comorbid conditions, mainly the NCD conditions such as hypertension, diabetes, cardiovascular diseases, respiratory diseases, cancer, kidney dysfunction, liver diseases, neurological disorder, autoimmune disorders, and other immunosuppressive conditions (20–22). Global evidence shows that severity and mortality have been reported at higher rates for male patients and older adults (18, 20, 22). Currently, available evidence shows that death occurs at an average of 17.8 days from the onset of COVID symptoms (23). Stories posted on social media platforms and media reporting of the situation have shown the miserable condition of health service delivery in Nepal, where people have been unable to access basic medicines or care in hospitals (particularly in areas with protracted lockdowns). Furthermore, it has been reported that patients who failed to present COVID reports were not allowed to receive inpatient care and that some patients lost their lives in search of a health care center or as a result of not having access to the ambulance services necessary to reach health facilities. WHO states that most people requiring treatment for NCDs like cancer, cardiovascular disease, and diabetes have not been able to receive health services and essential NCD medication as a consequence of the pandemic and the resultant lockdown imposed by central and local governments (12). This situation warrants urgent action to introduce innovative and alternative approaches to providing NCDs services. WHO also recommends including NCDs in the national response to and preparedness plans for managing the pandemic (13).

THE GOVERNMENT OF NEPAL'S RESPONSE TO THE COVID-19 PANDEMIC

Similar to many other countries, Nepal has massively endured unprecedented COVID pandemic with huge economic loss (24). To stop the rapid spread of SARS-CoV-2, the GoN has taken actions such as stay-at-home and mass quarantines (25). Movement restriction of people appears the most efficient non-clinical intervention to contain the spread of COVID, especially in resource-limited nations such as Nepal. At present, COVID cases are across the country because of inadequate implementation of the strategies and policies required for management of the overwhelming pandemic. However, the GoN is putting constant effort to curb the rapid transmission of SARS-CoV-2 at the community level.

Testing Strategies

In the earliest weeks of the COVID-19 pandemic, the health surveillance desk at Tribhuvan International Airport—the only international airport in the country—was initially authorized to screen all incoming passengers from affected regions around the globe (26). The government, under the leadership

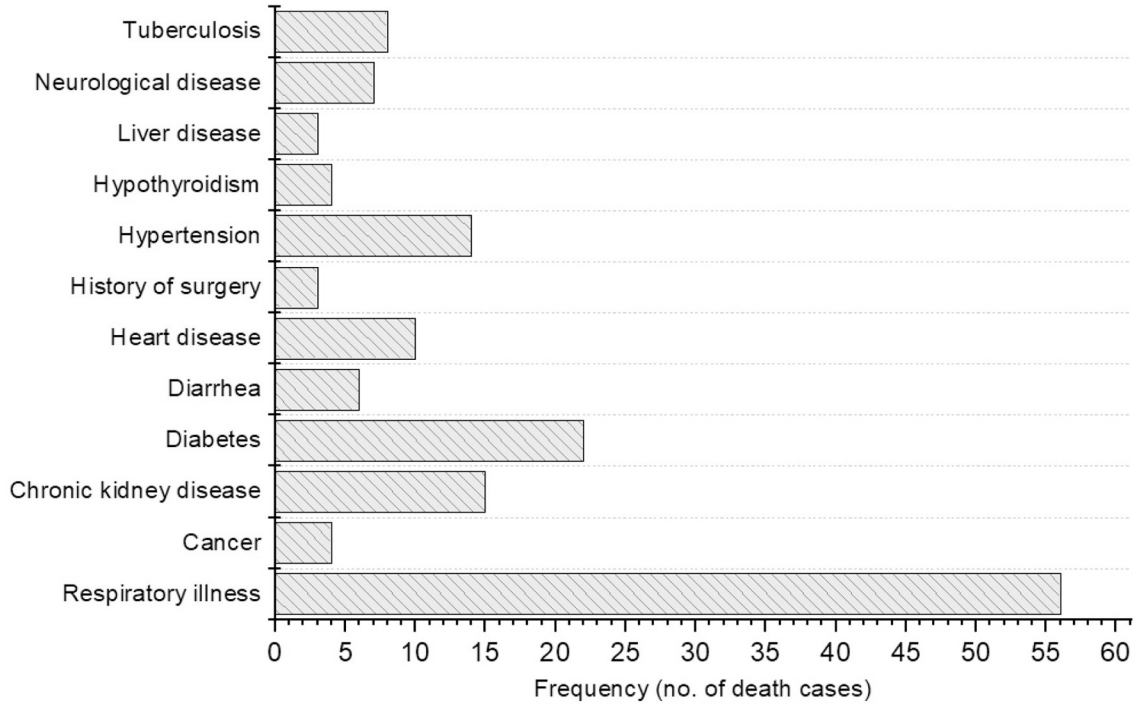

FIGURE 5 | Other underlying illness in deceased COVID-19 patients.

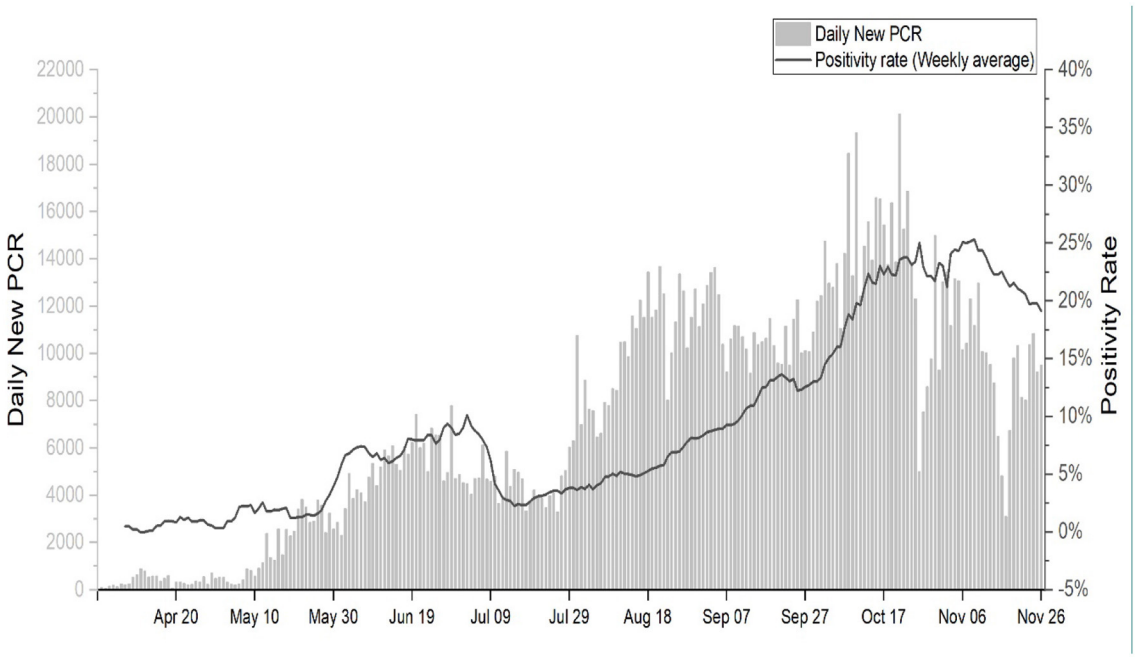

FIGURE 6 | Trend of daily RT-PCR and positivity rate.

of the home minister, formed a patient receiving team to transport the suspected patients to hospitals designated to receive COVID patients (27). RT-PCR tests were performed for quarantined individuals who displayed suspected COVID symptoms. Uninterrupted treatment services were prioritized by setting up twenty-five-bed hospitals. Additionally, the

government of Nepal has set up 36 COVID dedicated hospitals categorized into three levels: 16 Level 1 hospitals responsible for treating mild cases, 16 Level 2 hospitals for treating moderate cases, and four Level 3 to provide advance and specialized care for severe cases (28). All confirmed cases were shifted immediately and managed at COVID hospitals until they tested negative according to RT-PCR tests. In the meantime, the government ensured uninterrupted treatment services to non-COVID patients with life-and-limb-threatening conditions or injuries such as abscesses, acute pain, heart failure, acute exacerbation of COPDs, haemodialysis and ketoacidosis, among others (28). The GoN designated the Sukraraj Infectious and Tropical Disease Hospital (SITDH) in Kathmandu as the primary hospital for COVID treatment, along with the Patan Hospital and the Armed Police Forces Hospital. The government also designated specific spaces to be used for quarantine purposes throughout the country. The ground crossing points of entry at the Nepal-India border and the Nepal-China border were tightened in March 2020.

Contact Tracing

Effective systems to trace the contacts of those people who have come into contact with carriers of COVID-19 is essential to stop the rapid spread of the disease (29). With this in mind, the GoN has set up a system to screen individuals arriving in Kathmandu from other parts of the country or overseas by road or by air. Symptomatic passengers were taken directly to designated COVID hospitals and admitted, tested and treated appropriately. In contrast, asymptomatic passengers were kept in dedicated quarantine or advised to follow strict home quarantine and self-isolation and to avoid non-essential travel and community contact. Despite these regulations, there was no mechanism in place to monitor home quarantine and self-isolation.

In May 2020, the government formulated the Health Sector Emergency Response Plan (HSERP) to manage the spread of COVID-19. The plan suggested forming Case Investigation and Contact Tracing Teams (CICTTs) at the local level, which would include members from the public health, laboratory, nursing, local council, administration and security sectors (30). To date, most of the councils in the country have formed CICTTs. The main functions of the CICTTs are to ensure trained human resources at all levels, follow standard operating procedure (SOP) for case investigation and contact tracing, mobilize Female community health volunteers (FCHVs) at community levels, perform rapid epidemiological investigations of clusters at risk for COVID-19, and ensure necessary resources and protective measures to all care providers according to the estimated level of risk (31). These are essential functions for COVID-19 prevention and control and are outlined clearly as core functions of CICTTs. However, the key question remains whether these CICTTs are functioning effectively to trace contacts and ensure COVID testing for people at risk. So far, no detailed information or updates are available regarding the effectiveness of these CICTTs; however, several media reports suggest that CICTTs across the country have been inefficient and that this is a key area requiring the careful attention of the MoHP, to fight the spread of COVID-19 in Nepal.

Management of Quarantine and Isolation Centers

Media reports also show that quarantine facilities are becoming breeding centers for COVID-19 due to dangerous crowding, lack of facilities for sanitation and hygiene, poor residential environments (such as detainees sleeping on benches in communal rooms), poor medical care and social support and lack of nutritious food services (32). Institutional quarantine facilities have been arranged at schools, campuses, hostels, hotels and other accommodating facilities with the coordination of local government, and isolation facilities have been organized by the provincial governments and various public and private hospitals across the country. The mechanism developed by the government for monitoring the quarantine is ineffective in many places due to lack of proper coordination between stakeholders.

Public Information and Awareness Campaign

Disseminating correct information and education to the public is an effective measure to control and prevent the spread of any disease, especially in the time of the pandemic (28). The prevention of highly contagious and infectious disease is critically important (24). The Nepalese government, in collaboration with a range of sectors (both private and public) and other stakeholders, began developing and implementing information and awareness programs in the fight against COVID-19. Several public awareness campaigns designed to break the transmission chain were issued through text, audio and video platforms such as newspapers, flyers, radio and television. Despite these efforts, the potential risk of coronavirus transmission at the community level is not being taken seriously in Nepal, and this may be due to low health literacy level. Such negligence has been observed in media reports and social media stories that describe people found not following physical distancing practices in open places; for example, community dwellers observed selling and purchasing groceries in open markets without practicing physical distancing. The condition could worsen if the government fails to implement basic safety protocols; this could be achieved through awareness campaigns designed to encourage wearing masks properly in public places, using hand sanitiser, washing hands frequently, avoiding crowds and maintaining at least three meters of physical distance. These measures are needed especially considering upcoming festivals, which are celebrated by a large population of Hindu communities. Social media reports also show that some non-allopathic practitioners are openly distributing ineffective remedies and creating a false sense of security among the community. Local government bodies need to monitor these claims closely and take action against the spread of misinformation about treatments for COVID-19 (33).

Similarly, various protests for and against the ruling government have posed a significant challenge to authorities' efforts to contain the outbreak. Hundreds of young people chanting "Enough is Enough" have been descending on the streets of major cities across the country demanding a better and effective response from the government to curb the COVID-19 outbreak (34). While such protests and demonstrations would

be important to compel the government for its transparency, accountability, and response to people in terms of prevention and control of COVID-19, demonstrators and protestors need to comply with public health preventive advice such as using face masks properly and maintaining physical distancing, as suggested by WHO guidelines.

Nation-Wide Lockdown

On 2 March, in response to the ongoing pandemic, Nepal's government suspended the visa-on-arrival scheme for citizens of China, Hong-Kong, Japan, Italy and Iran, which are severely affected by COVID-19. The scheme was updated on 11 March and suspended for all nationals including non-residential Nepalese (NRN). On 18 March, the GoN planned to ban all passengers, including Nepalese nationals, from entering Nepal from European Union member countries, the United Kingdom, West Asia, the Gulf countries, South Korea and Japan; this ban was effective from midnight of 20 March 2020. On the same day a high-level coordination committee to fight against COVID-19, led by the defense minister, decided on the postponement of Secondary Education Examination (SEE) and university exams; the National Examinations Board (NEB) imposed a ban on all gatherings of more than 25 people. On 20 March, the government announced more measures to restrict outbreaks, including temporary bans on all flights, long-distance transportation across the country and all non-essential services. The government has included the following services in the essential services category: telephone and communication, transportation, civil aviation and airport, government press, defense affairs relating to arms, the production of military goods, internal security, drinking water, electricity, the residence of tourists, petroleum products, health and medicine and banking and insurance.

Amid concerns about SARS-CoV-2 spreading in the community, the government imposed a nation-wide lockdown effective 24 March, hours after the second COVID-19 case was confirmed. This measure was intended to last a week but was later extended to about four months. All national and international flights ceased, and all public and private vehicles were banned from March 22, 2020 except for those with prior permission from local authorities, those belonging to security forces, health workers and ambulances. Groceries and pharmacies operated during times specified by local authorities, while all other workplaces, government offices, school and universities were closed. Anyone who defies the government order is arrested under the Infectious Disease Control Act. According to the Act, violators are liable for a jail term of a month or hundred Nepalese rupees as fines, or with both penalties.

Recently, the Nepalese government decided to end the four-month-long lockdown effective from 22 July, with few restrictions, and to allow all domestic and international airlines to resume from 17 August 2020; however, it has again extended the restriction till 31 August 2020. In the context of celebrating "Visit Nepal 2020," the GoN also allowed hotels and restaurants to resume from 30 July while continuing all provisions related to COVID prevention, control and treatment strategies. Although the federal government has lifted the lockdown, some provincial and local authorities have re-imposed lockdown and other strategies to stop the further spread of SARS-CoV-2 in community. Some of these strategies include odd-even number vehicle movement, a complete prohibition of people from other districts, sealing commercial areas in some cities and ramping up contact tracing and testing at all levels of the government. Due to the second surge of COVID-19 in Nepal, province and districts are set to complete lockdown per the risk level.

Economic Support Package

Lockdown has impacted every sector of the country and disproportionately affected the poor, daily wage earners, and other marginalized groups in rural areas who have access to food and other services only through day-to-day basis work. In response, the government has established the "COVID-19 Prevention, Control and Treatment Fund" to which hundreds of institutions, business firm and individuals have made contributions. On 17 July, Nepal Rastra Bank, the central bank of Nepal, unveiled relief packages (35) through its annual monetary policy to mitigate the economic effects of COVID-19. These packages comprise an extension of loan repayment deadlines, refinance facilities, grace period extension for infrastructure projects and targeted lending in productive sectors at cheaper rates. On 27 July the bank categorized various sectors into three groups based on the level of impact caused by COVID-19: highly-affected, semi-affected, and least-affected (36).

Similarly, the government and other stakeholders have also introduced a relief package for laborers, poor and marginalized people, as well as distributing urgent foodstuffs; however, the implementation of such relief packages is not happening effectively due to unavailability of data on poor households, a lack of proper coordination among the involved stakeholders and the lack of a monitoring mechanism for distribution packages. Furthermore, the country's resources for curtailing the pandemic are being challenged by flooding and landslides in Hilly and Terai regions of the country as the monsoon season enters its peak. These natural disasters have affected hundreds of households and family, leaving many people homeless or living in emergency shelters, which are congested; thus, people can hardly maintain the recommended social distance, and many cannot afford the supplies necessary for good sanitation practices.

OPPORTUNITIES FOR THE GOVERNMENT OF NEPAL

We describe the priorities areas for the GoN (**Figure 7**) that are essential to overcoming and managing COVID.

Leadership and Management

In any uncertain situation, the population relies completely on leaders who are in a position to make crucial decisions during a challenging time. The government has created different committees and task teams for preparedness and response to COVID-19, but these committees have been criticized for not being able to perform preventive measures. In the current situation, the Nepalese leadership has been entangled in digressive topics: whether or not to accept the Millennium Challenge Corporation grant provided by

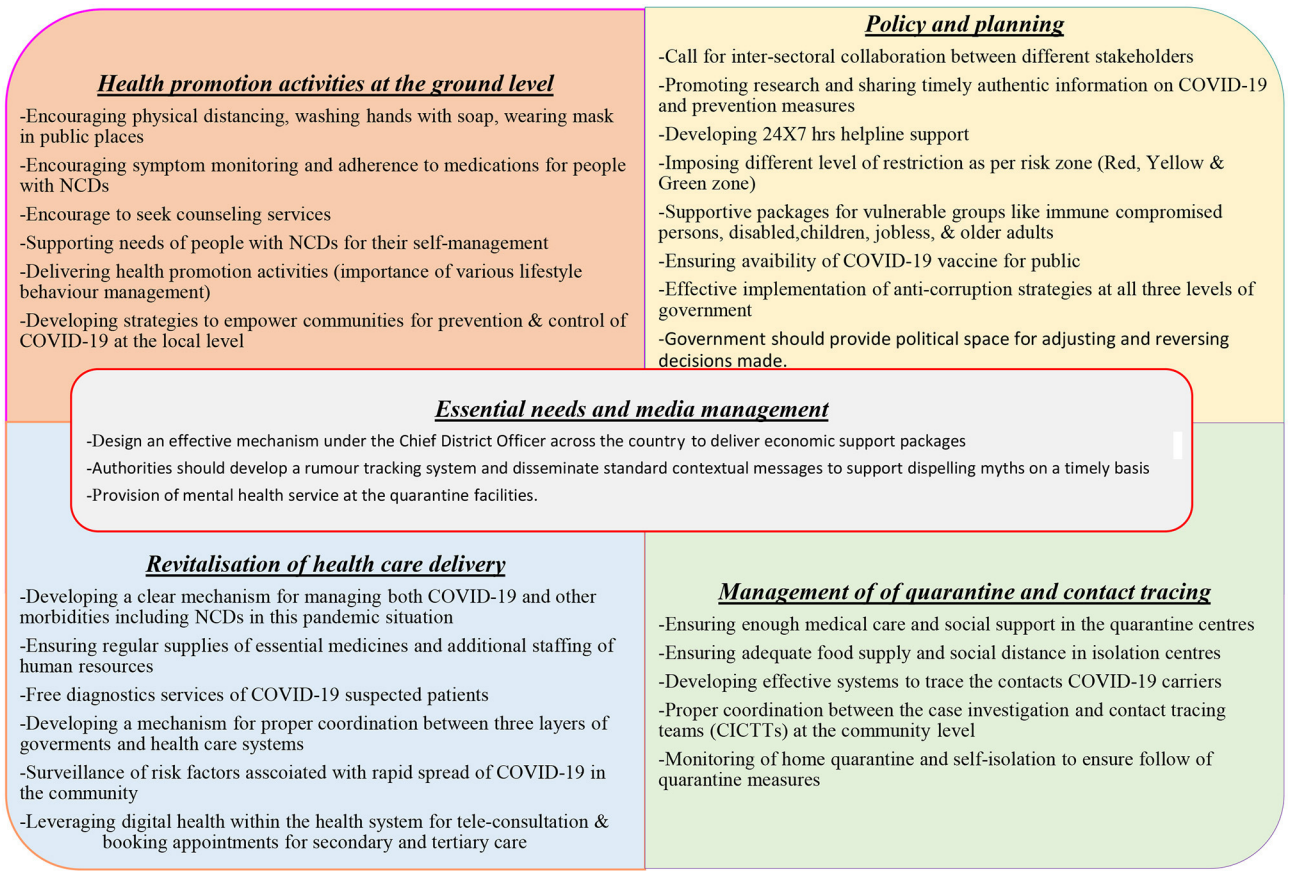

FIGURE 7 | Diagrammatic presentation showing the priorities areas for the improvement of COVID19 management.

the US government, whether Lord Ram (a Hindu God) was born in India or Nepal, whether new vehicles should be purchased for ministers and whether the ruling party prime minister should change. Moreover, the COVID-19 crisis has exacerbated several weaknesses including a scandal related to the procurement of Chinese personal protective equipment (PPE) and newly purchased but malfunctioning polymerase chain reaction (PCR) machines, delays in receiving expert opinions and expert disagreements with government decisions, understaffed and under-resourced public health care systems, a lack of media management, insufficient supplies and resources, poor planning and inter-sectoral collaboration and support, mismanaged quarantine, isolation centers, and testing processes and a lack of coordination between the three layers of the government system—federal, provincial, and local governments—in the management of this overwhelming condition.

The government should avoid the temptation of heroic leadership and instead need to listen to experts, implement anti-corruption strategies more effectively at all three levels of government (federal, provincial, and local level) and co-produce and implement policies for the effective management of an unpredictable condition that requires ultimate sacrifice from all politicians. It is also crucial that the government provide political space for adjusting and reversing decisions made. Government authorities need to engage the private sector in COVID management (37), which is not happening, with a few exceptions.

Essential Supplies, Media, and Quarantine Management

The lockdown imposed by authorities caused panic among the most marginalized and disadvantaged populations, particularly daily wage workers, older adults, people affected by natural disasters, people with disabilities and widow(er)s. To avoid such situations, the government should design an effective mechanism under the Chief District Officer across the country to deliver economic packages to the most affected population at the smallest administrative level which is ward area of each local government. The National Health Education Information Communication Center has developed standardized messages at the federal, provincial and local levels of government; however, misinformation and fake news about COVID-19 is spreading through social media platforms and online news

portals. Authorities should develop a rumor tracking system and disseminate standard contextual messages to support dispelling myths on a timely basis. Despite being a resource-constrained country, Nepal is trying its best to improve the conditions of its quarantine facilities. The poor quality of quarantine centers has led to rumors and discrimination against people who have had stayed there; the government must ensure that these facilities provide all basic amenities, including nutritious food, gender-friendly sleeping areas and clean toilets (38). Similarly, the provision of mental health service at the quarantine facilities would be a great support for people who are staying away from their family members (39). Moreover, separate isolation facilities for asymptomatic and symptomatic people, as well as a facility to refer patients to designated COVID-19 hospitals, would increase the smooth function and use of the quarantine facilities.

The Revitalisation of Health Care Delivery

The pandemic has exposed the long-standing fragile health care system of Nepal. The country has been battling the worst health effects while responding to COVID-19 with an under-resourced and understaffed health care system (40), and this has created a public demand throughout the country for quality and timely health services. Currently, secondary and tertiary health systems in Nepal are overwhelmed with the management of COVID-19 cases and, at the same time, the priority to address the needs of other infections and NCD has not been prioritized due to a lack of quality human resources, health system capacity and significant resource constraints. The Nepalese authorities need to develop a clear mechanism and system for managing both COVID-19 and other morbidities; compiling a list of operational COVID-19 and non-COVID-19 hospitals will enable people to receive health care services. Similarly, the government must strengthen primary health care services through regular supplies of essential medicines and extra staffing of human resources for health services; these efforts may reduce the patient burden on secondary and tertiary hospitals (41).

Moreover, the local government should manage ambulances with trained medical personnel to take the patients to the respective hospital so that patients can receive timely treatment. Similarly, leveraging digital health within the health system to provide teleconsultation and online appointment booking for secondary and tertiary care would be a benefit for patients. Local governments should not depend on every decision from a federal government, and it is high time that local governments ramp up contact tracing and testing by recruiting volunteers and installing PCR machines at the local levels. Finally, all three levels of government should develop and provide mental health advice and support platforms to help people to cope with the economic downturn, uncertain situations and the isolation, loneliness and anxiety that are creating a syndemic pandemic (41). It is equally important to consider the vulnerable and hard-to-reach rural communities as a part of the national response against the COVID.

COVID-19 VACCINATION STRATEGY AND ADAPTATION IN NEPAL

The scientists and researchers have worked around the clock with an unpredicted speed and finally it bought a ray of hope to fight the pandemic plight faced by global population. As said by WHO "A vaccine alone will not end this pandemic" means initial supply of vaccines will be prioritized for the high-risk and vulnerable population because of limited capacity of production and supplies in this unpredicted time. In the meantime, GoN should need to make a strategic plan and direct all energy and resources to prepare the country ready for availability of vaccines. Government should start working with GAVI COVAX Advance Market Commitment (AMC) to (42) ensure that vaccines are secured for Nepal with an effective delivery mechanism. Moreover, the country should start preparatory work (43) with experts of international and national levels, academics/researchers, international and national organizations, provincial and local governments to develop the protocols, mechanism for effective distribution and infrastructures required for rolling out the vaccines in timely and equitable way as soon as vaccine becomes available.

CONCLUSION

Along with the surge of COVID cases in Nepal, fatal cases are increasing, especially after the 4-month nation-wide lockdown was lifted. Numerous cases are being reported in southern Nepal, which shares a common border with India, as well as in other major cities in the country. Although older adults are considered more vulnerable to the infection of SARS-CoV-2, recent data from Nepal shows high case fatalities among younger patients as well. Respiratory illness, such as asthma and pneumonia are the most prevalent comorbidity associated with COVID mortality in Nepal. Executing the SOP for quarantine facilities effectively, increasing testing and effective contact tracing, and providing uninterrupted treatment for conditions other than COVID-19 may yield efficacious control of the pandemic in a resource-limited country like Nepal; more appropriate and effective measures for containing the rapid spread of SARS-CoV-2 are urgently necessary. A health literacy campaign and a clear strategy to care for older people and those with existing conditions like NCDs may also contribute to the effective management of the ongoing pandemic. As suggested by Torres et al. (44), this pandemic has worsened social equality in low-income countries including Nepal, and this needs to be addressed mainly by prioritizing marginalized and vulnerable populations. As reported in Nepal (37) and elsewhere (38) some patients show viral shedding 14 days after an initial positive test and may pose a risk of transferring the infection to a cluster or the broader community, therefore extending the current quarantine period of 14 days is recommended to minimize the spread of the virus. The Nepalese government should pay special attention to mass testing and quarantine management via the effective coordination of its three tiers of government (federal, provincial

and local) to control rapidly spreading SARS-CoV-2 in the local communities.

AUTHOR CONTRIBUTIONS

BR and UY designed the study. GS collected the data. BR, SK, and AP analyzed the data. AP, UY, and BR drafted and edited the manuscript. LR, SM, RP, BL, and SKM contributed significantly. All authors read and approved the final version of manuscript.

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REFERENCES

1. WHO. *Timeline: WHO's COVID-19 Response.* (2020). Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/interactive-timeline#! (accessed 10 August, 2020).
2. WHO. *Statement on the Second Meeting of the International Health Regulations (2005) Emergency Committee Regarding the Outbreak of Novel Coronavirus (2019-nCoV).* (2020). Available online at: https://www.who.int/news-room/detail/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov) (accessed August 10, 2020).
3. WHO. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 11 March 2020.* (2020). Available online at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-$-$11-march-2020 (accessed August 10, 2020).
4. Worldometer. *Coronavirus Update (Live): 20,810,774 Cases and 747,305 Deaths from COVID-19 Virus Pandemic – Worldometer.* (2020). Available online at: https://www.worldometers.info/coronavirus/ (accessed August 13, 2020).
5. SAARC Disaster Management Center. *COVID-19. SAARC Region.* (2020). Available online at: http://www.covid19-sdmc.org/ (accessed August 13, 2020).
6. Schafer H. *Standing with the people of South Asia in the fight against COVID-19.* World Bank Blogs (2020). Available online at: https://blogs.worldbank.org/endpovertyinsouthasia/standing-people-south-asia-fight-against-covid-19 (accessed August 13, 2020).
7. Ministry of Health and Population Government of Nepal. *01 SitRep_HEOC - Google Drive.* (2020). Available online at: https://drive.google.com/drive/folders/1QhLMbT76t6Zu1sFy5qlB5aoDbHVAcnHx (accessed August 10, 2020).
8. Ministry of Health and Population Government of Nepal. *SitRep#189_16-08-2020 - Google Drive.* (2020). Available online at: https://drive.google.com/drive/folders/1OcGKoZxTqdTWw6h0MfrEeXwg0PXaBaWa (accessed August 19, 2020).
9. World Health Organisation. *WHO Nepal Situation Updates on COVID-19.2020.* (2020). Available online at: https://www.who.int/nepal/news/detail/25-11-2020-who-nepal-situation-update (accessed November 26, 2020).
10. Bhattarai S, Dhungana J, Ensor T, Shrestha UB. Assessment of service availability and Infection prevention measures in hospitals of Nepal during the transition phase of COVID-19 case surge. *Medrxiv.* (2020), 1–18. Available online at: http://medrxiv.org/cgi/content/short/2020.05.13.20097675 (accessed August 19, 2020).
11. Cegolon L, Pichierri J, Mastrangelo G, Cinquetti S, Sotgiu G, Bellizzi S, et al. Hypothesis to explain the severe form of COVID-19 in Northern Italy. *BMJ Global Health.* (2020) 5:e002564. doi: 10.1136/bmjgh-2020-002564
12. WHO. *Rapid Assessment of Service Delivery for NCDs During the COVID-19 Pandemic.* (2020). Available online at: https://www.who.int/publications/m/item/rapid-assessment-of-service-delivery-for-ncds-during-the-covid-19-pandemic (accessed August 13, 2020).
13. WHO. *COVID-19 Significantly Impacts Health Services For Noncommunicable Diseases.* (2020). Available online at: https://www.who.int/news-room/detail/01-06-2020-covid-19-significantly-impacts-health-services-for-noncommunicable-diseases (accessed August 13, 2020).
14. Bhatraju PK, Ghassemieh BJ, Nichols M, Kim R, Jerome KR, Nalla AK, et al. COVID-19 in critically ill patients in the Seattle region—case series. *N. Engl. J. Med.* (2020) 382:2012–22. doi: 10.1056/NEJMoa2004500
15. Guan WJ, Liang WH, Zhao Y, Liang HR, Chen ZS, Li YM, et al. Comorbidity and its impact on 1,590 patients with Covid-19 in China: a nationwide analysis. *Eur. Respir. J.* (2020) 55:2001227. doi: 10.1183/13993003.01227-2020
16. Sanyaolu A, Okorie C, Marinkovic A, Patidar R, Younis K, Desai P, et al. Comorbidity and its impact on patients with COVID-19. *SN Compr. Clin. Med.* (2020) 2:1069–76. doi: 10.1007/s42399-020-00363-4
17. Our World in Data. *Nepal: Coronavirus Pandemic Country Profile.* (2020). Available online at: https://ourworldindata.org/coronavirus/country/nepal?country=~NPL (accessed November 26, 2020).
18. China CDC Weekly. The epidemiological characteristics of an outbreak of 2019 novel coronavirus diseases (COVID-19)—China, 2020. *China CDC Wkly.* (2020) 2:113–22. doi: 10.46234/ccdcw2020.032
19. Fisher D, Heymann D. Q&A: the novel coronavirus outbreak causing COVID-19. *BMC Med.* (2020) 18:57. doi: 10.1186/s12916-020-01533-w
20. Cao X. COVID-19: immunopathology and its implications for therapy. *Nat. Rev. Immunol.* (2020) 20:269–70. doi: 10.1038/s41577-020-0308-3
21. Deng G, Yin M, Chen X, Zeng F. Clinical determinants for fatality of 44,672 patients with COVID-19. *Crit. Care.* (2020) 24:179. doi: 10.1186/s13054-020-02902-w
22. Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, et al. OpenSAFELY: factors associated with COVID-19 death in 17 million patients. *Nature.* (2020) 584:430–6. doi: 10.1038/s41586-020-2521-4
23. Verity R, Okell LC, Dorigatti I, Winskill P, Whittaker C, Imai N, et al. Estimates of the severity of coronavirus disease 2019: a model-based analysis. *Lancet Infect. Dis.* (2020) 20:669–77. doi: 10.1016/S1473-3099(20)30243-7
24. Panthee B, Dhungana S, Panthee N, Paudel A, Gyawali S, Panthee S. COVID-19: the current situation in Nepal. *New Microb. New Infect.* (2020) 37:100737. doi: 10.1016/j.nmni.2020.100737
25. Kandel S, Lamsal M, Yadav SA, Bhandari D, Adhikari G, Poudel S, et al. Lifestyle, behavior, perception and practices of Nepalese during lockdown due to COVID-19 pandemic. *J. Nepal Med. Assoc.* (2020) 58:690–5. doi: 10.31729/jnma.5284
26. The Himalayan Times. *TIA Seeks Support, Cooperation From Public.* (2020). Available online at: https://thehimalayantimes.com/business/tia-seeks-support-cooperation-from-public/ (accessed August 13, 2020).
27. The Kathmandu Post. *Nepal Goes Under Lockdown for a Week Starting 6am.* Tuesday (2020). Available online at: https://kathmandupost.com/national/2020/03/23/nepal-goes-under-lockdown-for-a-week-starting-6am-tuesday (accessed August 13, 2020).
28. Ministry of Health and Population Government of Nepal. *COVID_and_non-CoVID_Health_Services_Guideline_02-01-2077.pdf - Google Drive.* (2020). Available online at: https://drive.google.com/file/d/1kzWQTtyi2cz8HSA4Hwv3zjdHwExJQXhO/view (accessed August 10, 2020).
29. Shrestha N, Pandey AR, Angdembe MR. Reflections from COVID-19 pandemic: contact diary for assessing social contact patterns in Nepal. *J. Nepal Health Res. Counc.* (2020) 18:340–1. doi: 10.33314/jnhrc.v18i2.2679
30. Ministry of Health and Population. Hospital-based interventions Public health and social measures Management and oversight Health Sector Emergency Response Plan COVID-19 Pandemic (2020).
31. Parajuli S, Shrestha S, Sah A, Kc H, Kapil Amgain D, Pyakurel P. Role of female community health volunteers for prevention and control of COVID-19 in Nepal. *J. Karnali Acad. Health Sci.* (2020) 3:1–6. doi: 10.3126/jkahs.v3i1.28847

32. Tamang P, Mahato P, Shahi P, Simkhada P, Van Teijlingen E, Kapil Amgain D. COVID-19 quarantine: a key part of prevention in Nepal (2020).
33. Caulfield T. Pseudoscience and COVID-19—we've had enough already. *Nature*. (2020). doi: 10.1038/d41586-020-01266-z. [Epub ahead of print].
34. My Republica. *Youth Demonstrators From 'Enough is Enough' Campaign Resume Protest - myRepublica - The New York Times Partner, Latest News of Nepal in English, Latest News Articles*. (2020). Available online at: https://myrepublica.nagariknetwork.com/news/youth-demonstrators-from-enough-is-enough-campaign-resume-protest/ (accessed August 13, 2020).
35. Xinhua News. *Nepal Unveils Monetary Policy to Revive Pandemic-Affected Businesses – Xinhua*. English.news.cn (2020). Available online at: http://www.xinhuanet.com/english/2020-07/18/c_139221642.htm (accessed August 10, 2020).
36. The Himalayan Times. *Nepal Rastra Bank Pins Relief to COVID Impact*. (2020). Available online at: https://thehimalayantimes.com/business/nepal-rastra-bank-pins-relief-to-covid-impact/ (accessed August 10, 2020).
37. Rasul G. A framework for improving policy priorities in managing COVID-19 challenges in developing countries. *Front. Public Health*. (2020) 8:589681. doi: 10.3389/fpubh.2020.589681
38. Plan International. *COVID-19 Quanrantine Centre Conditions Must Improve in Nepal*. Available online at: https://plan-international.org/blog/2020/06/covid-19-quarantine-centre-conditions-must-improve-nepal (accessed July 15, 2020).
39. Dhakal S. *Quarantined People can Suffer Mental Health Problems*. The Himalayan Times. Available online at: https://thehimalayantimes.com/nepal/quarantined-people-can-suffer-mental-health-problems/ (accessed November 26, 2020).
40. Hamal PK, Pokhrel N, Pandey D, Malla P, Lamsal R. Perspective of doctors for COVID-19 pandemic readiness in Government Hospitals of Nepal. *J. Nepal Health Res. Counc*. (2020) 18:166–71. doi: 10.33314/jnhrc.v18i2.2811
41. Yadav UN, Rayamajhee B, Mistry SK, Parsekar SS, Mishra SK. A syndemic perspective on the management of non-communicable diseases amid the COVID-19 pandemic in low- and middle-income countries. *Front. Public Health*. (2020) 8:508. doi: 10.3389/fpubh.2020.00508
42. Gavi The Vaccine Alliance. *The Gavi COVAX Advance Market Commitment (AMC)*. (2020). Available online at: https://www.gavi.org/vaccineswork/gavi-covax-amc-explained (accessed November 10, 2020).
43. Gupta GP, Shah Y, Pant DK, Lekhak S, Shahi R, Mandal A, et al. Preparatory phase for clinical trials of COVID-19 vaccine in Nepal. *Hum. Vaccines Immunother*. (2020) 1–2. doi: 10.1080/21645515.2020.1809267
44. Torres I, López-Cevallos DF, Sacoto F. Elites can take care of themselves - comment on COVID-19: the rude awakening for the political elite in low-income and middle-income countries. *BMJ Global Health*. (2020) 5:e003063. doi: 10.1136/bmjgh-2020-003063

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Attitude Toward Protective Behavior Engagement During COVID-19 Pandemic in Malaysia: The Role of E-government and Social Media

Norazryana Mat Dawi[1]*, *Hamidreza Namazi*[2,3], *Ha Jin Hwang*[1], *Suriani Ismail*[4], *Petra Maresova*[5] and *Ondrej Krejcar*[3,6]

[1] Sunway University Business School, Sunway University, Selangor, Malaysia, [2] School of Engineering, Monash University, Selangor, Malaysia, [3] Center for Basic and Applied Research, Faculty of Informatics and Management, University of Hradec Kralove, Hradec Kralove, Czechia, [4] Faculty of Medicine and Health Sciences, Universiti Putra Malaysia, Selangor, Malaysia, [5] Department of Economics, Faculty of Informatics and Management, University of Hradec Kralove, Hradec Kralove, Czechia, [6] Malaysia Japan International Institute of Technology (MJIIT), Universiti Teknologi Malaysia, Kuala Lumpur, Malaysia

The coronavirus disease 2019 (COVID-19) pandemic is still evolving and affecting millions of lives. E-government and social media have been used widely during this unprecedented time to spread awareness and educate the public on preventive measures. However, the extent to which the 2 digital platforms bring to improve public health awareness and prevention during a health crisis is unknown. In this study, we examined the influence of e-government and social media on the public's attitude to adopt protective behavior. For this purpose, a Web survey was conducted among 404 Malaysian residents during the Recovery Movement Control Order (RMCO) period in the country. Descriptive and multiple regression analyses were conducted using IBM SPSS software. Social media was chosen by most of the respondents ($n = 331$ or 81.9%) as the source to get information related to COVID-19. Multiple regression analysis suggests the roles of e-government and social media to be significantly related to people's attitudes to engage in protective behavior. In conclusion, during the COVID-19 outbreak, public health decision makers may use e-government and social media platforms as effective tools to improve public engagement on protective behavior. This, in turn, will help the country to contain the transmission of the virus.

Keywords: COVID-19, e-government, social media, protective behavior, attitude, Malaysia

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***Correspondence:**
Norazryana Mat Dawi
norazryana@outlook.com

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INTRODUCTION

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) or better known as coronavirus disease 2019 (COVID-19) first emerged in Wuhan, China, in December 2019. The disease then rapidly spread to many countries worldwide, and the World Health Organization (WHO) has declared the outbreak as a global pandemic on March 11, 2020 (1). According to the John Hopkins University COVID-19 dashboard (2), COVID-19 has infected millions of people and caused thousands of deaths worldwide. The pandemic also has pushed the healthcare system to its capacity and caused a global economic crisis.

Due to the rapid spread and absence of a vaccine or antiviral treatment, non-pharmaceutical interventions (NPIs) are the only available option to control the outbreak infection of respiratory viruses such as SARS-CoV-2 in a population (3). For instance, travel restrictions, school closures, and bans of public events have been imposed by governments across countries during the COVID-19 pandemic (4). Besides, people are advised to perform protective behavior, as recommended by WHO, such as wearing a face mask and maintaining social distance in public, regularly washing hands, staying at home, and self-isolating people with COVID-19 symptoms. Maximizing compliance with the recommended NPIs is important to delay the spread of the virus (5).

It is argued that individual behaviors in adopting protective behavior are more vital than government actions in controlling the spread of COVID-19 (6). Human behavior is the crucial element in framing the pandemic. Individuals will change their behavior spontaneously by adopting protective behavior when they perceive a high risk of infection and understand the severity of the disease. This behavior in return will help to reduce the transmission of the virus (7). However, a key problem is how the population perceives the risk to influence its engagement in protective behavior. According to the Theory of Reasoned Action (TRA), one of the factors that contribute to intended behavior is attitude (8). Attitude has long been recognized as a factor that leads people to perform a particular behavior (9). Attitude refers to the evaluative outcome of performing a specific behavior (8). If individuals have positive attitudes toward the suggested behavior, they are more likely to perform the behavior. Therefore, understanding individual attitudes toward protective behavior adoption is important to assess their adoption behavior and, consequently, enable public health authorities to assess the effectiveness of NPIs during the COVID-19 pandemic.

Risk communication strategies conducted by the government are highly effective and less costly NPIs during the COVID-19 outbreak (10). During a pandemic, people have a perception that the government has to play an active role to protect and ensure public safety (11). People will be motivated to engage in protective behavior when the government shows its determination to control the spread of the virus. Due to the restricted movement and social distancing, the COVID-19 pandemic has led to the urgency for e-government services. The United Nations stated that during the COVID-19 outbreak, governments around the world started using digital platforms such as portals, social media, and mobile applications to provide information related to COVID-19 to the public (12). Among the basic information given are travel restrictions, guidance on preventive measures, and governmental responses. The enhancement in e-governance during the COVID-19 pandemic has helped governments to combat the effects related to the pandemic (13). A study conducted in China reported that the use of social media by the Chinese government to provide the latest news in handling the COVID-19 crisis had positively affected public engagement (14).

In the past few years, there is an increase in governmental efforts to improve public communications using social media (15). With more than 3 billion users worldwide (16), social media could be the best platform to increase people's awareness and adherence to the recommended protective measures. Functions such as banners and pop-ups in social media are beneficial to alert users on new updates and to give reminders on protective behaviors such as social distancing and handwashing (17). Furthermore, the ability of social media to share real-time information will help to detect and combat infectious diseases. According to the social media analytics platform Sprinklr, there were about 19 million mentions of coronavirus across social media in 24 h after WHO announced COVID-19 as a pandemic (18). It shows the important role played by social media in disseminating information during the health outbreak.

E-government and social media are important platforms to supply information related to COVID-19 and to educate people on protective behavior. As people limit their physical interaction, stay more at home, and have more online time during the pandemic, their attitude toward protective behavior adoption could be influenced by the exposure to e-government and social media. However, there is still an unclear understanding of the roles played by these 2 variables in health promotion during a pandemic. In an investigation by Yasir et al. (11), results affirmed that there are positive relationships between the role of e-government and word of mouth with social presence during the COVID-19 outbreak. Further, Ahmad et al. (19) figured out that the government's guidelines on epidemic prevention influence individuals' intention to adopt COVID-19 prevention methods, while Nazir et al. (20) found that social media indirectly influences preventive behavior through awareness and information exchange. To the best of our knowledge, no study has been conducted to test the associations between e-government and social media with the attitude toward protective behavior during the COVID-19 pandemic. Therefore, empirical research is needed to test the relationships.

Malaysia is among the countries that were hit by the virus at the early stage of the outbreak due to its close location to China. The country detected the first case of COVID-19 on January 24, 2020, involving 3 tourists from Wuhan, China (21). To contain the spread of the virus, the Malaysian government has taken proactive actions such as health screening at all points of entry, compulsory quarantine for international travelers, increasing the number of hospitals to treat COVID-19 cases, setting up COVID-19 Fund, and implementation of Movement Control Order (MCO) (22).

Concerned about the importance of effective risk communication during the pandemic, the government of Malaysia relies heavily on e-government and social media to provide sufficient and up-to-date information to the public. Effective risk communication during a health crisis helps not only to relieve panic among society but also to promote adoption of protective measures (23). Malaysia residents can get information and updates on COVID-19 through the Official Portal of the Ministry of Health Malaysia, special Facebook pages called the Crisis Preparedness and Response Center (CRPC) and Kementerian Kesihatan Malaysia (KKM), and also Telegram channel of CPRC KKM (24). Daily press conference by the Director-General of Health provides consistent updates of COVID-19, which was broadcast

not only through television but also online streaming on Facebook. In April 2020, a mobile application called MySejahtera was launched by the government to help in managing the outbreak in the country. This application assists users to monitor their health progress and register their check-in locations, helping the authorities to gather early information and provide effective and fast responses to control the spread of COVID-19.

In June 2020, the Malaysian government reopened the economy and lifted some restrictions in phases as the number of cases had been declining (25). As of the date of writing, September 10, 2020, Malaysia's COVID-19 data show that there have been 9,628 total cases, 9,167 fully recovered, and 128 deaths. Even though Malaysia is facing downtrends of new and active COVID-19 cases, the condition is still concerning, as currently, there is still no vaccine available to fight the disease (26). Improving public attitudes toward adopting protective behavior is therefore of particular importance in this country. The purpose of this study was to explore the roles played by e-government and social media on Malaysian residents' attitudes to engage in protective behavior (**Figure 1**). It is deemed important to test the research framework in the context of Malaysia, as e-government and social media are used widely by health authorities for public health communications during the COVID-19 outbreak. It is argued that the successful interventions by the Malaysian government had improved the compliance and cooperation of the public to combat the disease (27). Assessing this phenomenon would be helpful for the public health decision makers to design preventive and mitigation strategies as the pandemic evolves. Given the above literature, we hypothesized the following:

H1: The role of e-government is positively related to attitude toward protective behavior engagement.

H2: The role of social media is positively related to attitude toward protective behavior engagement.

METHODOLOGY

Data for the study were collected using convenience and snowball sampling techniques. A Web-based survey was used to collect the data. Invitations to participate in the study were sent to Malaysian residents using multiple platforms such as social media, e-mail, and Messenger during the COVID-19 Recovery Movement Control Order (RMCO) period in the country. The questionnaire was prepared in English language, and a total of 404 participants have taken part in the survey. Most of the participants were Malaysians, and we also included non-Malaysians who were residing in the country. IBM SPSS Version 23 was used to conduct data cleaning, descriptive analyses, and multiple regression analysis. All the questions were adapted from different published literature and were modified to suit health promotion context during the COVID-19 outbreak. Specifically, 8 items for the role of the e-government were adapted from Parrey et al. (28) and Park and Lee (29), 9 items for the role of social media were adapted from Parrey et al. (28) and Karasneh et al. (30), and 9 items for the attitude toward protective behavior engagement were adopted from Ajzen and Fishbein (31) and World Health Organization (32). The instruments were given to 4 lecturers in health science and information systems to confirm that the concepts are appropriate for the health promotion context. Ethical approval was obtained from the Monash University Human Research Ethics Committee (Project ID: 24906).

RESULTS

Profile of Respondents

Table 1 presents the demographic characteristics of the 404 participants. There were 263 females (65.1%) and 141 males (34.9%) who were included in this study. The majority of the respondents (336) were young adults aged between 18 and

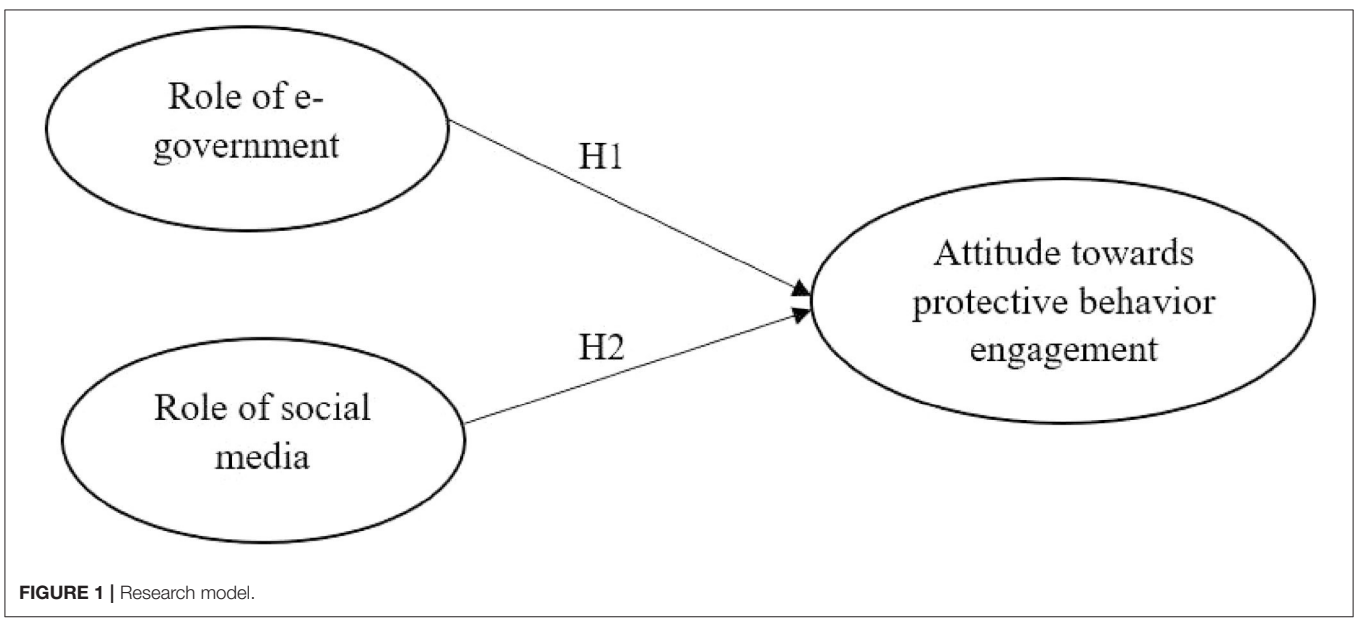

FIGURE 1 | Research model.

TABLE 1 | Participants' demographic profiles.

Variables	Frequency (*n*)	Percentage (%)
Gender		
Male	141	34.9
Female	263	65.1
Age		
18–24	336	83.2
25–34	29	7.2
35–44	24	5.9
45–54	12	3.0
55–64	3	0.7
Academic qualifications		
PhD	11	2.7
Master's degree	19	4.7
Bachelor's degree	207	51.2
Diploma	32	7.9
A-Level	121	30.0
Secondary/primary school	14	3.5
Nationality		
Malaysian	339	83.9
Non-Malaysian	65	16.1

TABLE 2 | Source to get information related to COVID-19.

Source of information	Frequency (*n*)	Percentage (%)
Ministry of health Malaysia website	176	43.6
Social media	331	81.9
Television/radio/newspaper	192	47.5
WHO website	85	21.0
Family/friends	156	38.6

COVID-19, coronavirus disease 2019.

24 years, which accounted for 83.2% of the total respondents. In terms of nationality, 83.9% ($n = 339$) of the sample were Malaysians, while the remaining 16.1% ($n = 65$) were non-Malaysians. The distribution by academic qualifications indicated that most of them ($n = 207$, 58.7%) held a bachelor's degree.

Participants were asked about the sources they used to get information related to COVID-19. This was a multiple-response question where participants can choose more than one answer. As shown in **Table 2**, 81.9% ($n = 331$) of the participants used social media to acquire COVID-19 information and 47.5% ($n = 192$) chose broadcast and print media (television, radio, and newspaper). The Ministry of Health Malaysia's website was chosen by 44.1% ($n = 176$) of the respondents, while 38.2% ($n = 156$) of them chose family/friends to get information related to COVID-19. Lastly, 21% ($n = 85$) of the respondents used the WHO website to obtain COVID-19 information.

Table 3 shows the results of the question on the source to get information related to COVID-19 compared against gender. The majority of the participants who have chosen social media as the source to get information were female ($n = 214$, 64.7%), and 35.3% ($n = 117$) were male. There is a significant difference between the gender that chose family/friends as the source to obtain information related to COVID-19; 111 (71.2%) were female, and only 45 (28.8%) were male. Almost similar distribution can be seen between gender on the options of the Ministry of Health Malaysia Website (42.6% or $n = 75$ male, 57.47% or $n = 101$ female) and WHO website (44.7% or $n = 38$ male, 55.3% or $n = 47$ female).

Table 4 highlights the distribution of answers on the question of the source to get information related to COVID-19 compared against the age group. Most participants who reported using social media as the source to get COVID-19 information were 18–24 years of age ($n = 283$, 85.5%) followed by participants aged 25–34 years ($n = 24$, 7.3%); 15 (4.5%) were 35–44 years of age, and 8 (2.4%) were aged 45–54 years. In comparison with other sources, most participants ($n = 18$, 10.2%) in the age group 35–44 years chose the Ministry of Health website to get information related to COVID 19. Additionally, 2 participants (1.0%) in the age group 55–64 years have chosen television/radio/newspaper as their source to obtain information related to COVID-19.

Reliability and Validity

The validity of the instrument was assessed by conducting factor analysis, and the internal consistency reliability was checked using Cronbach's alpha coefficient.

To validate whether respondents perceived the role of e-government and the role of social media to be distinct, a factor analysis with varimax orthogonal rotation was conducted. Bartlett's test of sphericity yielded a value of 3,553.934 and an associated level of significance smaller than 0.001, while the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy was 0.908. These indicate that there is a sufficient intercorrelation among the variables. KMO value >0.90 is considered "marvelous" (33). As can be seen in **Table 5**, the results of factor analysis validate that the two constructs are unidimensional and factorially distinct and that the items clustered on the constructs that they were supposed to represent.

The reliability of all scales was assessed based on Cronbach's alpha coefficient value. As shown in **Table 6**, Cronbach's alpha for the role of e-government, the role of social media, and attitude toward protective behavior were 0.884, 0.890, and 0.911, respectively, which were all above the threshold level of 0.7 (34). On average, respondents have a high level of agreement for all 3 constructs, with mean values higher than 3.

The assumptions of multiple linear regression were examined. Multicollinearity was checked using intercorrelations between the predictor variables. As shown in **Table 7**, the role of e-government and the role of social media were significantly ($p < 0.01$) correlated with values below the threshold of 0.7. In addition, the values of variance inflation factor (VIF) are <10 (both role of e-government and role of social media have similar values, tolerance = 0.826, VIF = 1.211), which indicate no violation of the regression assumptions of multicollinearity. The assumption of independent errors was met with the value of Durbin–Watson = 1.964. Lastly, an examination of the normal

TABLE 3 | Source to get information related to COVID-19 based on gender.

Variable	Gender				Total	
	Male		Female			
	n	%	*n*	%	*n*	%
Ministry of health Malaysia website	75	42.6	101	57.4	176	100
Social media	117	35.3	214	64.7	331	100
Television/radio/newspaper	74	38.5	118	61.5	192	100
WHO website	38	44.7	47	55.3	85	100
Family/friends	45	28.8	111	71.2	156	100

COVID-19, coronavirus disease 2019.

TABLE 4 | Source to get information related to COVID-19 based on age group.

Variable	Age										Total	
	18–24		25–34		35–44		45–54		55–64			
	n	%	*n*	%	*n*	%	*n*	%	*n*	%	*n*	%
Ministry of health Malaysia website	130	73.9	20	11.4	18	10.2	8	4.5	0	0.0	176	100
Social media	283	85.5	24	7.3	15	4.5	8	2.4	1	0.3	331	100
Television/radio/newspaper	162	84.4	13	6.8	12	6.3	3	1.6	2	1.0	192	100
WHO website	72	84.7	6	7.1	5	5.9	2	2.4	0	0.0	85	100
Family/friends	142	91	7	4.5	4	2.6	3	1.9	0	0.0	156	100

COVID-19, coronavirus disease 2019.

TABLE 5 | Factor analysis results.

Items	Factor	
	Role of e-government	Role of social media
The quality of information (e.g., daily update on cases, preventive methods) related to COVID-19 that the government provided through social media (e.g., Facebook, Twitter, Telegram) during the COVID-19 outbreak is satisfactory	0.677	
The online services I received from public servants (e.g., police, healthcare provider, immigration office, tax office) during the COVID-19 outbreak are satisfactory	0.631	
I feel the government is committed in curbing the COVID-19 outbreak by promoting a healthy lifestyle to the people through social media	0.691	
I feel the policies and regulations that the government is imposing during the COVID-19 outbreak are favorable for the people	0.702	
I consider the government as a trustworthy source for providing COVID-19 information	0.809	
I trust COVID-19 information acquired from the government is competent to help its citizens	0.829	
I trust the government in providing me with reliable information for protecting my safety from COVID-19	0.823	
I depend on the government to obtain COVID-19 information I need	0.693	
I consider opinion from social media while selecting information related to COVID-19		0.592
I feel social media is a good source to get information on COVID-19 preventive measures		0.751
I can change my opinion about COVID-19 based on updates reported in social media		0.719
Social media plays an important role in educating me about the procedures to follow in the event of COVID-19 outbreak		0.825
Social media plays an important role in increasing my knowledge of general preventive behaviors to control the infection		0.817
Social media plays an important role in spreading awareness of COVID-19 in the community		0.702
Social media plays an important role in educating people on how to protect others if they are ill		0.761
Social media plays an important role in decreasing fear, anxiety, and confusion about COVID-19 among people		0.619
I trust in what is posted on social media related to COVID-19		0.695

TABLE 6 | Descriptive statistics and scale reliability for each construct.

Construct	Items	Mean	Standard deviation	Cronbach's α
Role of e-government	8	4.112	0.580	0.884
Role of social media	9	3.836	0.616	0.890
Attitude	9	4.710	0.385	0.911

TABLE 7 | Intercorrelations of the main variables.

Variable	Attitude	Role of e-government	Role of social media
Attitude	1.000		
Role of e-government	0.362*	1.000	
Role of social media	0.258*	0.417*	1.000

*$p < 0.01$.

P-P plot of regression standardized residual of attitude toward protective behavior found that it looked normally distributed.

Hypothesis Testing

Multiple regression analysis was carried out to test the relationship between the role of e-government and the role of social media toward attitude toward protective behavior engagement. The results are presented in **Table 8**. The model was significant ($p < 0.01$) with *F*-value of 31.929. The coefficient of determination (R^2) value is 0.145, indicating that 14.5% variance in attitude toward protective behavior engagement is influenced by the role of e-government and the role of social media. The role of e-government ($\beta = 0.205$, $p < 0.01$) and the role of social media ($\beta = 0.081$, $p < 0.05$) were statistically significant predictors of attitude toward protective behavior engagement against COVID-19, supporting H1 and H2. A closer assessment of the β value showed that the role of e-government provides a greater influence on attitude compared to the role of social media.

DISCUSSION

During a pandemic such as COVID-19, an individual's adherence to health recommendations could be influenced by a variety of variables. From the results, we conclude that e-government and social media played significant roles in affecting Malaysian residents' attitudes toward protective behavior engagement.

Social media was chosen by most of the respondents as the source to obtain information related to COVID-19 followed by mass media. This was consistent with a study conducted by Mubeen et al. (35) to measure public awareness on COVID-19 transmission where social media was the most sought-after source of coronavirus followed by television. Another recently published study among nurses and physicians also found that social media was used to obtain information related to COVID-19 (36). This finding gives insight into the importance of public authorities to ensure that information related to the pandemic shared in social media is trustworthy and accurate.

The results of multiple regression analysis showed that e-government and social media positively predicted people's attitudes toward protective behavior engagement. This suggests the importance of continuing to provide credible information to the public through digital platforms. Our result was supported by Yasir et al. (11), who concluded that e-government gives a strong effect on the public's attitude toward quarantine during the COVID-19 outbreak in China. Government involvement in providing emergency information during an infectious disease outbreak contributes to protective behavior engagement (37, 38). People were more likely to follow public health recommendations if they were made aware of the reality of the crisis and how the government handles it (39). In addition, Park and Lee (29) figured out that e-government application was accepted by the public as a platform for public health risk communication.

Even though social media have long been acknowledged as the platform to spread false health information (40) and spreading panic during a health crisis (41), this study found that during the COVID-19 outbreak, social media is useful to influence the public to engage in protective behavior. Of note, the Malaysian government has taken serious action on misleading information related to COVID-19 posted on social media. A study by Azizan et al. (42) demonstrated that Malaysians expressed their solidarity and empowerment to fight the crisis on Facebook during the outbreak. This implies the positive effects given by social media to Malaysians in handling the unprecedented event. Our finding is consistent with that of Lin et al. (43) where they found a significant relationship between social media exposure and intention to implement preventive behavior. Indeed, social media has been regarded as an effective platform to communicate health information to the public (44).

This research has several limitations and future directions. Firstly, the sample size of this study is relatively small to generalize the population of Malaysian residents. A bigger study size should be carried out to get a better understanding of the situation. Secondly, the self-reported answers may be subject to bias, and respondents might have given socially desirable responses. Future studies may include a data collection method that does not require respondents to provide answers such as observation. Third, a previous study figured out that people's reactions to protective measures are varied across countries depending on their perceptions of their authorities (45). A comparative study between countries is recommended to extend the applicability of the current findings. Despite these limitations, the findings contribute to the understanding of the public attitude to engage in protective behavior in response to the COVID-19 outbreak in Malaysia.

CONCLUSION

As the COVID-19 outbreak continues, it is crucial to take effective measures to fight the pandemic effectively. Adherence to recommended protective behaviors such as washing hands regularly, wearing face masks, and physical distancing is

TABLE 8 | Result of multiple regression analysis.

Model	Unstandardized coefficients		*t*-test	*P*-value	*R*	R^2	*F*-test	*P*-value
	β	SE						
Constant	3.558	0.147	24.177	0.000	0.381	0.145	31.929	0.000
Role of e- government	0.205	0.035	5.874	0.000	N/A	N/A	N/A	N/A
Role of social media	0.081	0.033	2.473	0.014	N/A	N/A	N/A	N/A

important to ensure public health. A strong public attitude to support the preventive measures will allow minimizing the transmission of COVID-19. The findings of this study will benefit future planning if another outbreak wave occurs. E-government and social media have been proved to influence people's attitudes to engage in protective behavior. Thus, the authority should focus on improving digital services to ensure effective risk communication and information flow to the public during a pandemic and at the same time help to mitigate the spread of the disease.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Monash University Human Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

NM: conceptualized the idea, data collection, data analysis, and writing the original manuscript. HN: contributed to data collection and data analysis. HH: conceptualization and data collection. SI: conceptualization and editing original draft. PM: funding and edited the original draft. OK: funding and supervised this project. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed.* (2020) 91:157–60. doi: 10.23750/abm.v91i1.9397
2. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real time. *Lancet Infect Dis.* (2020) 20:533–4. doi: 10.1016/S1473-3099(20)30120-1
3. Qualls N, Levitt A, Kanade N, Wright-Jegede N, Dopson S, Biggerstaff M, et al. Community mitigation guidelines to prevent pandemic influenza - United States, 2017. *MMWR Recomm Rep.* (2017) 66:1–34. doi: 10.15585/mmwr.rr6601a1
4. Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. *Nature.* (2020) 584:257–61. doi: 10.1038/s41586-020-2405-7
5. Dardas LA, Khalaf I, Nabolsi M, Nassar O, Halasa S. Developing an understanding of adolescents' knowledge, attitudes, and practices toward COVID-19. *J School Nurs.* (2020) 36:430–41. doi: 10.1177/1059840520957069
6. Anderson RM, Heesterbeek H, Klinkenberg D, Hollingsworth TD. How will country-based mitigation measures influence the course of the COVID-19 epidemic? *Lancet Infect Dis.* (2020) 395:931–4. doi: 10.1016/S0140-6736(20)30567-5
7. Verelst F, Willem L, Beutels P. Behavioural change models for infectious disease transmission: a systematic review (2010-2015). *J R Soc Interface.* (2016) 13:1–20. doi: 10.1098/rsif.2016.0820
8. Fishbein M, Ajzen I. *Belief, Attitude, Intention, and Behavior: An Introduction to Theory and Research*. Reading, MA: Addison-Wesley (1975).
9. Ramayah T, Razak DA. Factors influencing intention to use diminishing partnership home financing. *Int J Islam Middle East Finance Manage.* (2008) 1:235–48. doi: 10.1108/17538390810901168
10. Haug N, Geyrhofer L, Londei A, Dervic E, Desvars-Larrive A, Loreto V, et al. Ranking the effectiveness of worldwide COVID-19 government interventions. *Nat Hum Behav.* (2020) 4:1303–12. doi: 10.1038/s41562-020-01009-0
11. Yasir A, Hu X, Ahmad M, Rauf A, Shi J, Nasir SA. Modeling impact of word of mouth and E-government on online social presence during COVID-19 outbreak: a multi-mediation approach. *Int J Environ Res Public Health.* (2020) 17:1–21. doi: 10.3390/ijerph17082954
12. United Nations. *COVID-19: Embracing Digital Government During the Pandemic and Beyond.* (2020). Available online at: https://www.un.org/development/desa/dpad/publication/un-desa-policy-brief-61-covid-19-embracing-digital-government-during-the-pandemic-and-beyond/ (accessed July 28, 2020).
13. Ullah A, Pinglu C, Ullah S, Abbas HSM, Khan S. The role of e-governance in combating COVID-19 and promoting sustainable development: a comparative study of China and Pakistan. *Chin Polit Sci Rev.* (2020) 6:86–118. doi: 10.1007/s41111-020-00167-w
14. Chen Q, Min C, Zhang W, Wang G, Ma X, Evans R. Unpacking the black box: how to promote citizen engagement through government social media during the COVID-19 crisis. *Comput Hum Behav.* (2020) 110:106380. doi: 10.1016/j.chb.2020.106380
15. Aladwani AM, Dwivedi YK. Towards a theory of SocioCitizenry: quality anticipation, trust configuration, and approved adaptation of governmental social media. *Int J Inform Manage.* (2018) 43:261–72. doi: 10.1016/j.ijinfomgt.2018.08.009

16. Statistica. *Social media - Statistics & Facts*. (2020). Available online at: https://www.statista.com/topics/1164/social-networks/ (accessed July 24, 2020).
17. Merchant RM, Lurie N. Social media and emergency preparedness in response to novel coronavirus. *JAMA*. (2020) 323:2011–2. doi: 10.1001/jama.2020.4469
18. Yammine S. Going viral: how to boost the spread of coronavirus science on social media. *Nature*. (2020) 581:345–6. doi: 10.1038/d41586-020-01356-y
19. Ahmad M, Iram K, Jabeen G. Perception-based influence factors of intention to adopt COVID-19 epidemic prevention in China. *Environ Res.* (2020) 190:109995. doi: 10.1016/j.envres.2020.109995
20. Nazir M, Hussain I, Tian J, Akram S, Tshiaba SM, Mushtaq S, et al. A multidimensional model of public health approaches against COVID-19. *Int J Environ Res Public Health*. (2020) 17:3780. doi: 10.3390/ijerph17113780
21. Raghu A. *Malaysia Reports First Confirmed Cases of Novel Coronavirus*. (2020). Available online at: https://www.bloomberg.com/news/articles/2020-01-25/malaysia-reports-first-confirmed-cases-of-novel-coronavirus (accessed July 24, 2020).
22. Malaysian Ministry of Health. *Covid-19 Malaysia*. (2020). Available online at: http://covid-19.moh.gov.my/ (accessed July 24, 2020).
23. Yusof ANM, Muuti MZ, Ariffin LA, Tan MKM. Sharing information on COVID-19: the ethical challenges in the Malaysian setting. *Asian Bioethics Rev.* (2020) 12:349–61. doi: 10.1007/s41649-020-00132-4
24. My Government. (2020). Avaialble online at: https://www.malaysia.gov.my/portal/content/30936 (accessed July 24, 2020).
25. Chu MM. *Malaysia to Reopen Most Economic Activity With Virus Outbreak 'Under Control'*. (2020). Available online at: https://www.reuters.com/article/us-health-coronavirus-malaysia-curbs/malaysia-to-reopen-most-economic-activity-with-virus-outbreak-under-control-idUSKBN23E08N (accessed July 24, 2020).
26. World Health Organization. *Q&A: Influenza and COVID-19 - Similarities and Differences*. (2020). Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/question-and-answers-hub/q-a-detail/q-a-similarities-and-differences-covid-19-and-influenza (accessed July 6, 2020).
27. Tang KHD. Movement control as an effective measure against Covid-19 spread in Malaysia: an overview. *J Public Health*. (2020) 1–4. doi: 10.1007/s10389-020-01316-w
28. Parrey SH, Hakim IA, Rather RA. Mediating role of government initiatives and media influence between perceived risks and destination image: a study of conflict zone. *Int J Tour Cities*. (2019) 5:90–106. doi: 10.1108/IJTC-02-2018-0019
29. Park H, Lee TD. Adoption of E-government applications for public health risk communication: government trust and social media competence as primary drivers. *J Health Commun*. (2018) 23:712–23. doi: 10.1080/10810730.2018.1511013
30. Karasneh R, Al-Azzam S, Muflih S, Soudah O, Hawamdeh S, Khader Y. Media's effect on shaping knowledge, awareness risk perceptions and communication practices of pandemic COVID-19 among pharmacists. *Res Sock Adm Pharm*. (2020) 17:1897–902. doi: 10.1016/j.sapharm.2020.04.027
31. Ajzen I, Fishbein M. *Understanding Attitudes and Predicting Social Behavior*. Englewood Cliffs, NJ: Prentice-Hall (1980).
32. World Health Organization. *Coronavirus Disease (COVID-19) Advice for the Public*. (2020). Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/advice-for-public (accessed July 24, 2020).
33. Kaiser HF. An index of factorial simplicity. *Psychometrika*. (1974) 39:31–6. doi: 10.1007/BF02291575
34. Nunnaly JC. *Psychometric Theory*. New York, NY: McGraw-Hill (1978).
35. Mubeen SM, Kamal S, Kamal S, Balkhi F. Knowledge and awareness regarding spread and prevention of COVID-19 among the young adults of karachi. *J Pak Med Assoc*. (2020) 70:S169–74. doi: 10.5455/JPMA.40
36. Elhadi M, Msherghi A, Alkeelani M, Zorgani A, Zaid A, Alsuyihili A, et al. Assessment of healthcare workers' levels of preparedness and awareness regarding COVID-19 infection in low-resource settings. *Am J Trop Med Hygiene*. (2020) 103:828–33. doi: 10.4269/ajtmh.20-0330
37. Chon M-G, Park H. Predicting public support for government actions in a public health crisis: testing fear, organization-public relationship, and behavioral intention in the framework of the situational theory of problem solving. *Health Commun*. (2019) 9:1–11. doi: 10.1080/10410236.2019.1700439
38. Al-Hasan A, Yim D, Khuntia J. Citizens' adherence to COVID-19 mitigation recommendations by the government: a 3-country comparative evaluation using web-based cross-sectional survey data. *J Med Internet Res*. (2020) 22:e20634. doi: 10.2196/preprints.20634
39. Dai B, Fu D, Meng G, Liu B, Li Q, Liu X. The effects of governmental and individual predictors on COVID-19 protective behaviors in China: a path analysis model. *Public Admin Rev*. (2020) 80:797–804. doi: 10.1111/puar.13236
40. Allington D, Duffy B, Wessely S, Dhavan N, Rubin J. Health-protective behaviour, social media usage, and conspiracy belief during the COVID-19 public health emergency. *Psychol Med*. (2020) 1–7. doi: 10.1017/S003329172000224X
41. Ahmad AR, Murad HR. The impact of social media on panic during the COVID-19 pandemic in iraqi kurdistan: online questionnaire study. *J Med Internet Res*. (2020) 22:e19556. doi: 10.2196/preprints.19556
42. Azizan M, Ismail HH, Qaiwer SN. Power and solidarity in positive facebook postings amidst COVID-19 in Malaysia. *J Nusant Stud Jonus*. (2020) 5:329–64. doi: 10.24200/jonus.vol5iss2pp329-364
43. Lin Y, Hu Z, Alias H, Wong LP. Influence of mass and social media on psychobehavioral responses among medical students during the downward trend of COVID-19 in Fujian, China: cross-sectional study. *J Med Internet Res*. (2020) 22:e19982. doi: 10.2196/preprints.19982
44. Abd-Alrazaq A, Alhuwail D, Househ M, Hai M, Shah Z. Top concerns of tweeters during the COVID-19 pandemic: a surveillance study. *J Med Internet Res*. (2020) 22:e19016. doi: 10.2196/preprints.19016
45. Wei HL, Lindell MK, Prater CS, Wei J, Wang F, Ge YG. Perceived stakeholder characteristics and protective action for influenza emergencies: a comparative study of respondents in the UniteStates and China. *Int J Mass Emerge Disast*. (2018) 36:52–70.

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Psychological Stress Risk Factors, Concerns and Mental Health Support Among Health Care Workers in Vietnam During the Coronavirus Disease 2019 (COVID-19) Outbreak

Phuong Thi Lan Nguyen[1†], *Tien Bao Le Nguyen*[2†], *Anh Gia Pham*[3†], *Khanh Ngoc Cong Duong*[4,5,6†], *Mac Ardy Junio Gloria*[4,7†], *Thanh Van Vo*[2,8], *Bay Van Vo*[9] *and Toi Lam Phung*[4,10*]

[1] Social Economics and Administrative Pharmacy Program, Department of Pharmacy, Faculty of Pharmacy, Mahidol University, Bangkok, Thailand, [2] Institute of Orthopaedics and Trauma Surgery, Viet Duc Hospital, Hanoi, Vietnam, [3] Oncology Department, Viet Duc Hospital, Hanoi, Vietnam, [4] Mahidol University Health Technology Assessment Graduate Program, Mahidol University, Bangkok, Thailand, [5] School of Medicine, Vietnam National University, Ho Chi Minh City, Vietnam, [6] Vietnam National University, Ho Chi Minh City, Vietnam, [7] Department of Pharmacy, College of Pharmacy, University of the Philippines Manila, Manila, The Philippines, [8] Department of Surgery, Hanoi Medical University, Hanoi, Vietnam, [9] Department of Pharmacy, Thong Nhat Hospital, Ho Chi Minh City, Vietnam, [10] Health Strategy and Policy Institute, Ministry of Health, Hanoi, Vietnam

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***Correspondence:**
Toi Lam Phung
phunglamtoi@hspi.org.vn

[†] These authors have contributed equally to this work and share first authorship

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Introduction: Coronavirus disease 2019 (COVID-19) has significantly affected health care workers (HCWs), including their mental health. However, there has been limited evidence on this topic in the Vietnamese context. Therefore, this study aimed to explore COVID-19-related, psychological stress risk factors among HCWs, their concerns and demands for mental health support during the pandemic period.

Methods: We employed a cross-sectional study design with convenience sampling. An online, self-administered questionnaire was used and distributed through social media among medical and non-medical HCWs from April 22 to May 12, 2020. HCWs were categorized either as frontline or non-frontline. We measured the prevalence of psychological stress using the Impact of Event Scale-Revised (IES-R) instrument. Multivariate binary logistic regression analysis was performed to identify risk factors associated with psychological stress among HCWs.

Results: Among the 774 enrolled participants, 761 (98.3%) eligible subjects were included in the analysis. Most respondents were females (58.2%), between 31 and 40 years of age (37.1%), lived in areas where confirmed COVID-19 cases had been reported (61.9%), medical HCWs (59.9%) and practiced being at the frontline (46.3%). The prevalence of stress was 34.3%. We identified significant risk factors such as being frontline HCWs (odds ratio [OR] = 1.77 [95% confidence interval [CI]: 1.17–2.67]), perceiving worse well-being as compared to those before the COVID-19 outbreak [OR = 4.06 (95% CI: 2.15–7.67)], and experiencing chronic diseases [OR = 1.67 (95% CI: (1.01–2.77)]. Majority (73.9%) were concerned about testing positive for COVID-19 and exposing the infection to their families. Web-based psychological interventions that could provide knowledge on managing mental distress and consulting services were highly demanded among HCWs.

Conclusion: The prevalence of psychological stress among HCWs in Vietnam during the COVID-19 pandemic was high. There were also significant risk factors associated with it. Psychological interventions involving web-based consulting services are highly recommended to provide mental health support among HCWs.

Keywords: COVID-19, healthcare worker, risk factor, psychological stress, mental health

INTRODUCTION

At the end of 2019, the world witnessed the emergence of a novel pneumonia caused by a severe acute respiratory syndrome coronavirus 2–SARS-CoV-2, known as the coronavirus disease 2019 (COVID-19) (1). COVID-19 was then declared a global pandemic by the World Health Organization (WHO) on 11 March 2020 with 118,000 confirmed cases and 4,291 deaths across 114 countries (2). Its rapid surge from thousands up to millions of cases has raised attention worldwide (3). COVID-19 hit Vietnam for the first time on 23 January 2020. Also, last 20 March 2020, Vietnam documented the first two COVID-19 cases in female nurses at a frontline hospital in the country's capital (4). The country initially succeeded in fighting the first wave of the disease and its transmission since 22 April 2020. (4). However, on 25 July 2020, a positive case which was identified at a provincial hospital marked the resurgence of the outbreak (4). On 13 September 2020, Vietnam had documented 1,060 cases with 910 recoveries and 35 deaths (4).

During the pandemic, Vietnamese government has implemented preventive measures such as the nationwide closure of schools and non-essential businesses, border control, social distancing, and regulation for wearing masks in public in order to contain the spread of COVID-19 (5, 6). Furthermore, healthcare workers (HCWs) have played a vital role in battling against COVID-19, not only for providing care to the society, but also directly being involved in the treatment of confirmed cases among hospitals designated for COVID-19 care in the country (7). HCWs contributed to numerous epidemiological actions, including early detection of cases, isolation, tracing cases, and close monitoring of either suspected cases or close contact groups (6, 7). While the general public had been urged to maintain social distancing and remain at home to minimize disease transmission, HCWs were prepared to do the opposite (5). As such, HCWs are more likely to have psychological health problems such as stress, anxiety, depression and insomnia (8).

The negative psychological burden of working under an infectious disease environment is prominent and inevitable (9).

Previous evidence suggested that HCWs were emotionally affected and traumatized during outbreaks, like in the case of severe acute respiratory syndrome (SARS) in 2003 (10, 11). In fact, HCWs during an outbreak might experience the fear of being infected and other unfavorable conditions, such as increasing number of confirmed cases, excessive workload, shortage of personal protective equipment, and intense media scrutiny, that could increase their risk of developing psychological problems (12). They, therefore, suffered from sleep disorders with worse sleep quality and sleep time reduction aside from anxiety and guilt (13). An observational cohort study in the United Kingdom and the United States of America indicated that frontline HCWs were 11 times more likely to contract COVID-19 than the general community (14). Such psychological impact would not only burden HCWs' well-being but might also hinder their ability to effectively manage COVID-19 (15, 16). Furthermore, a systematic review on the mental health problems faced by HCWs during the COVID-19 pandemic reported that the disease can be an independent risk factor for stress among HCWs (17).

Vietnam documented the first two COVID-19 cases on HCWs which were nurses at a frontline hospital in the first wave of the pandemic. Alarmingly, the resurgence of the outbreak in Vietnam in July at a provincial hospital had added 14 COVID-19 cases among HCWs (4). As such, Vietnam's Ministry of Health has made efforts to alleviate the pressure for HCWs, such as sending more medical staff to reduce workload, implementing infection control programs, giving personal protective equipment, and providing financial support to frontline HCWs (4). Nevertheless, these efforts focused only on managing their physical health. With the unpredictability and complexity of COVID-19, understanding its psychological impacts for the timely provision of mental health support to HCWs is essential during the pandemic. Notably, there has been limited evidence on the psychological impact among HCWs, their concerns, as well as the mental health support demand during the COVID-19 pandemic in Vietnam. Therefore, this present study aimed to examine the psychological stress among HCWs, identify factors associated with it, and explore the demand for psychological support among HCWs during COVID-19 pandemic.

MATERIALS AND METHODS

Study Population

A cross-sectional study design was conducted using a self-administered questionnaire. HCWs were defined as people engaged in providing and delivering care and services to patients (18). The inclusion criteria are subjects being a HCW, working in the health facilities in Vietnam, volunteering to participate in the study. The study excluded people working in other sectors not related to health care, people working in health facilities but not involving in delivering care and services to patients such as accountant, information technology, recruiter, and security. Data were collected from 24 April to 12 May 2020.

Frontline HCWs were people involved in the epidemiological investigation, testing, treatment and management of COVID-19 patients, while non-frontline HCWs included healthcare staff who were providing services to patients not related to COVID-19 (19). Physicians and nurses were categorized as medical HCWs, while pharmacists and health technicians were classified as non-medical HCWs (20).

Questionnaire

A survey questionnaire was developed to obtain data for research. This included information on socio-demographic characteristics, and a tool to assess HWCs' mental health, their concerns related to COVID-19 and their need for mental health support.

Socio-Demographic Characteristics

This part included age, sex (male or female), living area (having COVID-19 cases or not), marital status (single, married or divorced/separated/widowed), educational attainment (intermediate, college, undergraduate or post-graduate), job category (medical HCW or non-medical HCW), working department (treatment or prevention), health facility level (central, provincial, district, commune or private health facility), years of working experience (<5, 5–10, 10–20 or >20 years), whether being at the frontline in the COVID-19 taskforce, whether the respondent had chronic diseases, self-perceived change in respondent's health status (better, almost unchanged, worse or much worse), whether the respondent experienced being quarantined, change in workload during COVID-19 outbreak (increased, unchanged, decreased or temporary off). In Vietnamese context, people with "intermediate degree" in educational attainment refers to those who entered medical high school. Frontline HCWs were defined as those directly engaged in treating patients with confirmed COVID-19.

Mental Health Assessment

The Impact of Event Scale-Revised (IES-R) was used to assess the psychological response associated with trauma for different specific life events (21). Previous studies reported that this questionnaire could assess stress conditions with satisfactory reliability and validity among Vietnamese and with other countries' sample population (22–26). The scale consisted of three dimensions (avoidance, intrusion, and hyperarousal) with a total of 22 entries. Responses were based on a five-point Likert scale (not at all, a little bit, moderately, quite a bit and extremely). The total score ranged from 0 to 88, with a higher score corresponding to a greater stress level. The result was interpreted based on four groups: normal (score 0–23), mild (score 24–32), moderate (score 33–36), and severe (score $\geq$ 37) stress.

COVID-19 Concerns and Mental Health Support

To determine COVID-19-related concerns among HCWs and their need for mental health support, questions were adapted from previous studies (27, 28) and modified to reflect Vietnamese context. In the paper about understanding HCWs during the COVID-19 pandemic, they indicated eight sources of

TABLE 1 | Socio-demographic characteristics among HCWs during the COVID-19 outbreak in Vietnam ($n = 761$).

Variables	*n* (%)
Age group	
18–25	77 (10.1)
26–30	193 (25.4)
31–40	282 (37.1)
>40	209 (27.4)
Gender	
Male	318 (41.8)
Female	443 (58.2)
Living area having COVID-19 cases	
Yes	471 (61.9)
No	290 (38.1)
Marital status	
Single	247 (32.5)
Married	491 (64.5)
Divorced, separated, or widowed	23 (3.0)
Educational attainment	
Intermediate	67 (8.8)
College	72 (9.5)
Undergraduate	395 (51.9)
Postgraduate	227 (29.8)
Job title	
Medical HCW	456 (59.9)
Non-medical HCW	305 (40.1)
Working Department	
Treatment	594 (78.1)
Preventive health	97 (12.7)
Community care	32 (4.2)
Others[a]	38 (5.0)
Experience in being quarantined	
Yes	107 (14.1)
No	654 (85.9)
Health facility levels	
Central health facility	194 (25.5)
Provincial health facility	255 (33.5)
District health facility	121 (15.9)
Commune health station	19 (2.5)
Private health facility	151 (19.8)
Others[a]	21 (2.8)
Working experience (years)	
<5	206 (27.1)
5–10	230 (30.2)
10–20	207 (27.2)
>20	118 (15.5)
Responsibility for COVID-19 taskforce	
Frontline	211 (27.7)
Non-frontline	550 (72.3)
Chronic disease	
Yes	91 (12.0)
No	670 (88.0)

(Continued)

TABLE 1 | Continued

Variables	*n* (%)
Self-perceived health status compared to before COVID-19 outbreak	
Better	48 (6.3)
Almost unchanged	653 (85.8)
Worse	60 (7.9)
Much worse	0 (0.0)
Workload during COVID-19 outbreak	
Increased workload	88 (11.6)
Unchanged workload	413 (54.3)
Decreased workload	220 (28.9)
Temporary off work	40 (5.2)

[a] *Schools, universities, research institutes, pharmaceutical companies.*

anxiety among HCWs when working under the pandemic (28). We utilized these sources to ask whether Vietnamese HCWs concerned about it. Regarding mental health support, three multiple-choice questions were asked to explore the content that HCWs were interested in, their preferred resources, and who they would like to receive care from. These contents were adapted from Kang's study which explored the psychological care need among medical and nursing staff in Wuhan (27).

Data Collection

An online questionnaire was established using the Google form platform due to the social distancing strategy and restriction of face-to-face contact. Using convenience sampling, the survey link was circulated through personal contacts and social media networks (e.g., Facebook) and mobile apps in Vietnam (e.g., Zalo). The respondents accessed the link and voluntarily responded to the survey.

Ethical Consideration

The study protocol was approved by the Institutional Review Board of Thong Nhat Hospital, Ho Chi Minh city, Vietnam (IRB approval number: 10/BB-BVTN). The questionnaires used in the study were anonymized. Informed consent of the participants was obtained prior to data collection.

Data Analysis

We performed descriptive statistics and presented the results as frequency (percentage) or median with an interquartile range (IQR). The score of the IES-R was expressed as median (IQR). Chi-square test or Fisher's exact test was employed to examine the associations among stress, COVID-19-related concerns and needs of mental health support, where appropriate. Univariate and multivariable logistic regression analyses were conducted to identify risk factors associated with psychological stress. The IES-R scores of <23 and ≥ 23 were classified as normal psychological status and having psychological stress, respectively (21). Respondents' socio-demographic characteristics were considered as explanatory factors. A p-value of <0.25 in the univariate analysis was used as a cut-off point to include variables in multivariable logistic regression (29). The strength of associations among variables was reported as odds ratios (OR) with 95% confidence interval (CI). A p-value ≤ 0.05 was considered statistically significant. All analyses were performed using Stata version 14.0 (StataCorp, College Station, Texas 77845 USA).

RESULTS

Sociodemographic Characteristics

From a total of 774 HCWs who completed the survey, 761 (98.3%) subjects were eligible for analysis. **Table 1** shows the socio-demographic characteristics of the respondents. We found that the median age was 34 years, where the 31–40 age group accounted for the highest proportion (37.1%). Most were females (58.2%), lived in areas with confirmed COVID-19 cases (61.9%), married (64.5%), attained undergraduate level (51.9%), and medical HCWs (59.9%). Also, many respondents worked in a treatment unit (78.1%), at a provincial health facility (33.5%) and had 5–10 years of working experience (30.2%). A total of 211 (27.7%) respondents were frontline HCWs in the COVID-19 taskforce. Also, about 12.0% had chronic diseases and 14.1% experienced quarantine. When asked regarding their current health status as compared with that before COVID-19 outbreak and their workload during the COVID-19 outbreak, majority (85.8%) answered as unchanged.

Stress Severity Level and Predictors of the Psychological Stress Outcome

We found that 34.3% HCWs had psychological stress symptoms. **Supplementary Tables 1**, **2** (**Supplementary Data**) illustrate the results from the logistic regression models of potential predictors of psychological stress among HCWs. From these, we identified significant risk factors, such as being frontline HCWs [OR = 1.77 (95% CI: 1.17–2.67)], perceiving as worse health status as compared to that before the COVID-19 outbreak [OR = 4.06 (95% CI: 2.15–7.67)], and having chronic diseases [OR = 1.67 (95% CI: (1.01–2.77)]. As for educational attainment, HCWs having either a college degree or a bachelor's degree showed less stress as compared with those who got an intermediate degree [OR = 0.30 (95% CI: 0.14–0.69), OR = 0.45 (95% CI: 0.25–0.81), respectively]. As for marital status, HCWs who were divorced, separated, or widowed were less likely to have psychological stress as compared with those who were single [OR = 0.18 (0.04–0.86)].

COVID-19-Related Concerns

Table 2 presents the COVID-19-related concerns among HCWs. When asked about their concerns related to working during the outbreak, majority (73.9%) answered being exposed to COVID-19 at work and taking the infection to their families. This was followed by a concern on access to appropriate personal protective equipment (56.5%). Some participants (37.3%) were also worried about not having a rapid access to testing if they developed COVID-19 symptoms and the concomitant fear of propagating infection at work. Only 10.2% felt nervous about having limited access to up-to-date information and

TABLE 2 | The association between stress severity level of HCWs and their COVID-19-related concerns during the COVID-19 outbreak in Vietnam.

Concerns	Severity of stress [Number (%)]					*p*-value
	Total ($n = 761$)	Normal ($n = 500$)	Mild ($n = 113$)	Moderate ($n = 51$)	Severe ($n = 97$)	
Access to appropriate personal protective equipment	430 (56.5)	271 (54.2)	61 (54.0)	29 (56.9)	69 (71.1)	0.020
Being exposed to COVID-19 at work and taking the infection home to their family	562 (73.9)	351 (70.2)	92 (81.4)	45 (88.2)	74 (76.1)	0.006
Not having rapid access to testing if they develop COVID-19 symptoms and concomitant fear of propagating infection at work	284 (37.3)	167 (33.4)	44 (39.0)	28 (54.9)	45 (46.4)	0.004
Uncertainty that their organization will support/take care of their personal and family needs if they develop infection	237 (31.1)	132 (26.4)	39 (34.5)	22 (43.1)	44 (45.4)	<0.001
Access to childcare during increased work hours and school closures	248 (32.6)	129 (25.8)	54 (47.8)	22 (43.1)	43 (44.3)	<0.001
Support for other personal and family needs as work hours and demands increase (food, hydration, lodging, transportation)	186 (24.4)	89 (17.8)	37 (32.7)	20 (39.2)	40 (41.2)	<0.001
Being able to provide competent medical care if deployed to a new area (e.g., non-ICU nurses having to function as ICU nurses)	224 (29.4)	131 (26.2)	38 (33.6)	15 (29.4)	40 (41.2)	0.019
Lack of access to up-to-date information and communication	78 (10.2)	40 (8.0)	11 (9.7)	10 (19.6)	17 (17.5)	0.004

communication. As for stress severity level, HCWs were the most anxious about being exposed to COVID-19 at work and taking the infection home (>70% in all levels). Notably, the proportion of respondents having COVID-19-related concerns increased with higher stress level.

Psychological Care Needs

Table 3 shows the results on the psychological care needs among HCWs. As for contents of interest, among HCWs with normal psychological status, almost half (43.8%) did not feel the necessity to have access to mental health support. Nevertheless, those with either severe or moderate stress levels wanted to gain skills to self-rescue themselves and to help others alleviate psychological distress. As for the desired platform to obtain such competence, half of the respondents preferred a website where they can access psychological knowledge. When they were asked about whom they would like to receive care from, most answered friend or colleagues (37.2%) or psychologists and psychiatrists (31.9%). Among HCWs with severe stress levels, most (48.5%) agreed to need help from psychologists.

DISCUSSION

To the authors' knowledge, this study is the first mental health investigation amongst HCWs in the wake of COVID-19 outbreak in Vietnam. The analysis included 761 respondents, with a 34.3% prevalence of psychological stress symptoms among them. The study showed that majority were females, aged 31–40 years, lived in areas having confirmed COVID-19 cases, medical HCWs, attained undergraduate level, married, and worked in provincial health facilities at the treatment unit for 5–10 years. We also found that working in the COVID-19 task force team, perceiving a worse well-being compared to that before the COVID-19 outbreak, having chronic diseases were independent predictors for having psychological stress outcomes. Most HCWs were concerned about their fear of being exposed to COVID-19 and taking the infection home. Findings also suggested the demand for psychological support, in which, most of HCWs wished to have a website provided with psychological knowledge. Moreover, those who have severe stress levels would like to receive care from either psychiatrists or their colleagues.

In this study, a proportion of 34.3% of HCWs reported stress symptoms. This finding was similar to the stress prevalence related to COVID-19 among the Vietnamese general population (35.9%) (30). Compare to the pooled prevalence of stress in Asia, this figure was a little bit lower (34.3% vs. 41.3%) (31). Notably, this figure was about half of the prevalence in China as reported in a study conducted by Lai et al. where more than 70.0% had stress disorders during the outbreak (19). This could be explained by the fact that the outbreak's impact in China, which was the original epicenter of the coronavirus, was more serious and acute as compared with Vietnam. Particularly, during the time when these two studies were conducted, Vietnam had only 413 COVID-19 cases, while China had more than 80,000 positive cases (3). Another reason was that our sample population focused

TABLE 3 | The association between stress severity level and needs of mental health support among HCWs during the COVID-19 outbreak in Vietnam.

Content of interest	Severity of stress [Number (%)]					*p*-value*
	Total (*n* = 761)	Normal (*n* = 500)	Mild (*n* = 113)	Moderate (*n* = 51)	Severe (*n* = 97)	
Knowledge of psychology	264 (34.7)	163 (32.6)	47 (41.6)	18 (35.3)	36 (37.1)	0.308
Skills for self-rescue	284 (37.3)	154 (30.8)	52 (46.0)	25 (49.0)	53 (54.6)	**<0.001**
Skills for help others alleviate psychological distress	258 (33.9)	136 (27.2)	42 (37.2)	30 (58.8)	50 (51.6)	**<0.001**
Seek help from psychologists or psychiatrists	78 (10.2)	35 (7.0)	13 (11.5)	8 (15.7)	22 (22.7)	**<0.001**
Not necessary	292 (38.4)	219 (43.8)	39 (34.5)	12 (23.5)	22 (22.7)	**<0.001**
Resources						
Paper sources (books, brochures, etc.)	127 (16.7)	63 (12.6)	18 (15.9)	21 (41.2)	25 (25.8)	**<0.001**
Website provided with psychological resources	382 (50.2)	241 (48.2)	52 (46.0)	29 (56.9)	60 (61.9)	0.051
Group psychotherapy	74 (9.7)	42 (8.4)	7 (6.2)	7 (13.7)	18 (18.6)	**0.007**
Individual counseling and psychotherapy	74 (9.7)	38 (7.6)	11 (9.7)	8 (15.7)	17 (17.5)	**0.010**
Uninterested	7 (0.9)	6 (1.2)	0 (0.0)	0 (0.0)	1 (1.0)	0.579**
Prefer to receive care from						
Psychologists or psychiatrists	258 (33.9)	153 (30.6)	42 (37.2)	16 (31.4)	47 (48.5)	**0.006**
Family or relatives	243 (31.9)	147 (29.4)	41 (36.3)	19 (37.3)	36 (37.1)	0.229
Friends or colleagues	283 (37.2)	160 (32.0)	45 (39.8)	29 (56.9)	49 (50.5)	**<0.001**
Do not need help	25 (3.3)	16 (3.2)	6 (5.3)	0 (0.0)	3 (3.1)	0.399**

Chi-square test/Fisher's exact test. Bold values have a meaning that they are less than 0.05 which indicated that there was a significant difference between severity of stress and the need for those content of interest.*

on HCWs from all sectors, while Lai et al. employed a hospital-based survey, which may involve higher risks for exposure to COVID-19 and thus could lead to increased fear of spreading the virus and being isolated (19). The prevalence was also much lower compared to that in USA of 60.2% (31). Although USA is a high-income country with advanced health care system, HCWs in this country still suffered from stress because of the overwhelming COVID-19 cases and deaths.

Notably, HCWs working at the frontline had at least 2-fold increased risk for having psychological stress as compared with those not at the frontline. This finding resonated with Lai's study in China and Alshekaili's study in Oman which reported that frontline HCWs were around 1.5 times more likely to develop psychological stress than non-frontline HCWs (19, 32). Evidently, having direct and frequent contact with confirmed or suspected COVID-19 patients has been well-recognized to render frontline HCWs vulnerable to suffer from stress disturbances as it places them at an increased risk of infection that might threaten their lives (14). In Italy, as of 16 April 2020, about 17,000 frontline HCWs tested positive to COVID-19, and 127 of them succumbed to the disease (33). This implies that HCWs are under a huge risk of threatening their lives due to the COVID-19 crisis, which in turn could lead to higher psychological stress. As such, our study suggests that continuous efforts aimed at improving the mental well-being should be focused among HCWs who are directly treating and managing patients with COVID-19. Moreover, we found that HCWs who perceived a negative change in their health status as compared with that before COVID-19 were likely to have psychological stress. This finding conformed with another cross-sectional study on mental health among medical and nurse staff where the group perceiving their health status as worse than before COVID-19 had the highest prevalence of severe stress (27).

Furthermore, we also found evidence that the risk of having stress among HCWs with chronic diseases was double that of those without such diseases. Indeed, chronic diseases, such as heart disease, stroke, diabetes mellitus, and cancer may increase susceptibility to COVID-19 (34). This was proven in a meta-analysis where patients with pre-existing chronic diseases were about 3.5 times more likely to develop severe COVID-19 and be admitted to an intensive care unit as compared with those who had none (34). Specifically, compared to COVID-19 patients with no pre-existing chronic diseases, COVID-19 patients who had diabetes, hypertension, cardiovascular disease, or chronic pulmonary disease had a higher risk of developing severe disease, with an OR (95% CI) of 2.61 (1.93–3.52), 2.84 (2.22–3.63), 4.18 (2.87–6.09), and 3.83 (2.15–6.80), respectively (34). Therefore, future intervention should be targeted to these groups.

HCWs who attained a college degree or bachelor's degree were less likely to have psychological stress than those with intermediate degree. This may be explained by the fact that higher educational background may have more professional knowledge on exposure patterns and transmission characteristics of COVID-19 (35–37); thus, they might have a good awareness and understanding of the disease and could manage better their

situations. Likewise, divorced HCWs were less likely to have psychological stress than those who were single. This difference may be due to the maturity between these subjects, such that those who failed in their marriage may have gone through more challenges and events as they got older which helped them to deal with the crisis better.

As for concerns when working during the pandemic, most HCWs expressed their hope of not acquiring the infection so that they can protect their family from being infected since they may be a potential carrier for COVID-19 transmission. Despite of the adequate provision of personal protective equipment (PPE) for HCWs in Vietnam, this concern was unavoidable because COVID-19 exposure among Vietnamese HCWs were high. Indeed, in Vietnam, HCWs contributed on all fronts from prevention, screening to diagnosis and treatment of COVID-19 when the COVID-19 hit the country (6). Moreover, the Vietnamese government imposed extensively an intensive tracing and tracking of people who have been contacted with infected people; when a confirmed case was identified, the authorities would trace contact from the confirmed case to the fourth level of contact (6). This required a large number of HCWs workforce involving in COVID-19 testing for a high volume of patients with different degrees of pathology and severity. Noteworthy, their concern was exacerbated by the risk of working place, the increased workload and information from social media in the country as well (6, 38). High risk of infection of HCWs was also related to the pernicious and unpredictable characteristic of COVID-19 as asymptomatic infections (39). Furthermore, proper caution is advised considering that a vaccine to address the outbreak is still being developed (40).

Apart from social demographic factors discussed in the study context, other factors were found to be related stress outcomes among HCWs. Banerjee reported that in China and the United Kingdom (UK) which are countries with high COVID-19 cases, physician developed stress due to the increased witness to death, the increased risk of exposure and self-blame, and guilt of spreading the infection to the family members (13). Psychiatric disorders such as anxiety, sleep disturbances, and depression commonly co-occurs with posttraumatic stress disorder (41). In the systematic review of psychological well-being in South Asia, these psychological comorbidities were reported to be suffered by HCWs in two studies in India (13).

As for the needs for mental health support, HCWs with severe or moderate stress levels wanted to have skills for managing themselves and for helping others relieve psychological distress. They also preferred a website to access such knowledge. Friends or colleagues were the ones HCWs trusted the most to share their problems. Since this was the first study in the country that examined the concerns and demands regarding mental health support among HCWs, our results suggest that interventions should focus on developing a web-based platform that could provide psychological resources which might help HCWs perceive and manage stress. Also, HCWs' friends and families should be encouraged to access this website so that they can help and support them to recognize, understand and overcome psychological issues. The interface and content of the website should be less complicated and easily comprehensible so that both HCWs and the general population could apply the knowledge in improving their mental health and assert their vital role when they have a HCW family member working during the pandemic. In addition, telehealth project has been released in Vietnam to provide remote consultation and treatment since September 2020 (42). Thereby, the authorities could take tele-psychological services into considerations during the pandemic. However, the psychological-mindedness of the HCWs should also be considered as whether they are willing to seek help or feel social stigma.

Some limitations should be highlighted in this study. Firstly, a self-administered questionnaire through online platform could be biased depending upon the respondents' mood prior to answering it. Whereas, they might feel too burdened to respond to the survey or not at all interested in answering it. Second, the study employed a cross-sectional design within 2 weeks and did not assess the psychological stress symptoms in the following period. Because of the negative unpredictable situation brought about by the COVID-19 outbreak, the respondents' psychological symptoms could become worse after the period of data collection. Third, lack of qualitative component to understand the concerns of HCWs in depth. Moreover, the study did not exclude people with a history childhood abuse or who are being treated with psychological problems, which might overestimate the study results. Lastly, this study used only a single scale (IES-R) which focused only the psychological stress aspect without other common psychiatric comorbidities. As such, consideration should be given to the extent other mental health problems, such as insomnia, depression, or anxiety, which could provide a more comprehensive picture of the mental health impact on HCWs during the outbreak. Given these limitations, further studies covering more psychological aspects are recommended and employing a probability sampling technique with a larger sample size would be needed to verify the results.

CONCLUSION

Overall, this study highlighted the prevalence of psychological stress among HCWs during the COVID-19 period in Vietnam. It was found that there was a higher risk of having stress among HCWs who were at the frontline, perceived their health status as worse as compared with that before the pandemic, and experienced chronic diseases. Most HCWs were worried about being a potential source of infection to their families. Given the context of an ongoing resurgence of COVID-19 in the country and with more complicated cases whose some of their sources were still not known, the mental health of HCWs may deteriorate more and get worse. Therefore, psychological interventions are highly recommended to provide mental health support among HCWs. Additionally, health authorities should be responsible in protecting the psychological well-being of HCWs during the pandemic. Furthermore, further research will be needed to investigate comprehensively psychological well-being of HCWs during and post-pandemic along with policy strategies to measure it properly.

DATA AVAILABILITY STATEMENT

The original contributions generated for this study are included in the article/**Supplementary Material**, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Review Board of Thong Nhat Hospital, Ho Chi Minh city, Vietnam. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

PN, TN, AP, KD, MG, TV, BV, and TP: conceptualization and writing—review and editing. PN, TN, AP, KD, BV, and TP: methodology. PN, TN, AP, KD, MG, TV, and TP: data curation. PN, TN, AP, KD, and MG: data analysis. PN, KD, TV, and AP: writing—original draft preparation. TP: supervision. PN, TN, AP, KD, and TP: project administration. All authors contributed to the article and agreed to the submitted version of the manuscript.

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SUPPLEMENTARY MATERIAL

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REFERENCES

1. Lai C-C, Shih T-P, Ko W-C, Tang H-J, Hsueh P-R. Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) and corona virus disease-2019 (COVID-19): the epidemic and the challenges. *Int J Antimicrob Agents*. (2020) 55:105924. doi: 10.1016/j.ijantimicag.2020.105924
2. World Health Organization. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-11 March 2020* (2020). Available online at: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19---11-march-2020 (accessed August 11, 2020).
3. World Health Organization. *WHO Coronavirus Disease (COVID-19) Dashboard 2020* [cited 2020 11th August]. Available online at: https://covid19.who.int/ (accessed August 11, 2020).
4. Vietnam's Ministry of Health. *Information About Coronavirus Diease Outbreak COVID-19 2020* [cited 2020 12 August]. Available online at: https://ncov.moh.gov.vn/ (accessed February 1, 2021).
5. Dinh L, Dinh P, Nguyen PD, Nguyen DH, Hoang T. Vietnam's response to COVID-19: prompt and proactive actions. *J Travel Med*. (2020) 27:taaa047. doi: 10.1093/jtm/taaa047
6. Ha BTT, La Quang N, Mirzoev T, Tai NT, Thai PQ, Dinh PC. Combating the COVID-19 epidemic: experiences from Vietnam. *Int J Environ Res Public Health*. (2020) 17:3125. doi: 10.3390/ijerph17093125
7. Van Minh H. Proactive and comprehensive community health actions to fight the COVID-19 epidemic: initial lessons from Vietnam. *J Rural Health*. (2021) 37:148. doi: 10.1111/jrh.12430
8. Pappa S, Ntella V, Giannakas T, Giannakoulis VG, Papoutsi E, Katsaounou P. Prevalence of depression, anxiety, and insomnia among healthcare workers during the COVID-19 pandemic: a systematic review and meta-analysis. *Brain Behav Immun*. (2020) 88:901–7. doi: 10.2139/ssrn.3594632
9. Preti E, Di Mattei V, Perego G, Ferrari F, Mazzetti M, Taranto P, et al. The psychological impact of epidemic and pandemic outbreaks on healthcare workers: rapid review of the evidence. *Curr Psychiatry Rep*. (2020) 22:1–22. doi: 10.1007/s11920-020-01166-z
10. Chan AO, Huak CY. Psychological impact of the 2003 severe acute respiratory syndrome outbreak on health care workers in a medium size regional general hospital in Singapore. *Occup Med*. (2004) 54:190–6. doi: 10.1093/occmed/kqh027
11. Wu P, Fang Y, Guan Z, Fan B, Kong J, Yao Z, et al. The psychological impact of the SARS epidemic on hospital employees in China: exposure, risk perception, and altruistic acceptance of risk. *Can J Psychiatry*. (2009) 54:302–11. doi: 10.1177/070674370905400504
12. Oladunjoye A, Oladunjoye O. An evolving problem-mental health symptoms among health care workers during COVID-19 pandemic. *Asian J Psychiatr*. (2020) 54:102257. doi: 10.1016/j.ajp.2020.102257
13. Banerjee D, Vaishnav M, Sathyanarayana Rao T, Raju M, Dalal P, Javed A, et al. Impact of the COVID-19 pandemic on psychosocial health and well-being in South-Asian (World Psychiatric Association zone 16) countries: a systematic and advocacy review from the Indian Psychiatric Society. *Indian J Psychiatry*. (2020) 62:343–53. doi: 10.4103/psychiatry.IndianJPsychiatry_1002_20
14. Nguyen LH, Drew DA, Graham MS, Joshi AD, Guo C-G, Ma W, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. *Lancet Public Health*. (2020) 5:e475–83. doi: 10.1101/2020.04.29.20084111
15. Maunder RG, Lancee WJ, Balderson KE, Bennett JP, Borgundvaag B, Evans S, et al. Long-term psychological and occupational effects of providing hospital healthcare during SARS outbreak. *Emerg Infect Dis*. (2006) 12:1924. doi: 10.3201/eid1212.060584
16. Kang L, Li Y, Hu S, Chen M, Yang C, Yang BX, et al. The mental health of medical workers in Wuhan, China dealing with the 2019 novel coronavirus. *Lancet Psychiatr*. (2020) 7:e14. doi: 10.1016/S2215-0366(20)30047-X
17. Spoorthy MS, Pratapa SK, Mahant S. Mental health problems faced by healthcare workers due to the COVID-19 pandemic–a review. *Asian J Psychiatry*. (2020) 51:102119. doi: 10.1016/j.ajp.2020.102119
18. Joseph B, Joseph M. The health of the healthcare workers. *Indian J Occup Environ Med*. (2016) 20:71. doi: 10.4103/0019-5278.197518
19. Lai J, Ma S, Wang Y, Cai Z, Hu J, Wei N, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open*. (2020) 3:e203976. doi: 10.1001/jamanetworkopen.2020.3976
20. Tan BY, Chew NW, Lee GK, Jing M, Goh Y, Yeo LL, et al. Psychological impact of the COVID-19 pandemic on health care workers in Singapore. *Ann Intern Med*. (2020) 173:317–20. doi: 10.7326/M20-1083
21. Weiss DS. *The Impact of Event Scale: Revised. Cross-Cultural Assessment of Psychological Trauma and PTSD*. New York, NY: Springer (2007). p. 219–38. doi: 10.1007/978-0-387-70990-1_10
22. Craparo G, Faraci P, Rotondo G, Gori A. The Impact of Event Scale–Revised: psychometric properties of the Italian version in a sample of flood victims. *Neuropsychiatr Dis Treat*. (2013) 9:1427. doi: 10.2147/NDT.S51793
23. Malinauskiene V, Bernotaite L. The Impact of Event Scale–Revised: psychometric properties of the Lithuanian version in a sample of employees exposed to workplace bullying. *Acta Med Litu*. (2016) 23:185. doi: 10.6001/actamedica.v23i3.3384
24. Creamer M, Bell R, Failla S. Psychometric properties of the impact of event scale—revised. *Behav Res Ther*. (2003) 41:1489–96. doi: 10.1016/j.brat.2003.07.010
25. Sveen J, Orwelius L, Gerdin B, Huss F, Sjöberg F, Willebrand M. Psychometric properties of the Impact of Event Scale-Revised in patients one year after burn injury. *J Burn Care Res*. (2010) 31:310–8. doi: 10.1097/BCR.0b013e3181d0f523

26. Chen CS, Cheng CP, Yen CF, Tang TC, Yang P, Yang RC, et al. Validation of the Impact of Event Scale-Revised for adolescents experiencing the floods and mudslides. *Kaohsiung J Med Sci*. (2011) 27:560–5. doi: 10.1016/j.kjms.2011.06.033
27. Kang L, Ma S, Chen M, Yang J, Wang Y, Li R, et al. Impact on mental health and perceptions of psychological care among medical and nursing staff in Wuhan during the 2019 novel coronavirus disease outbreak: a cross-sectional study. *Brain Behav Immun*. (2020) 87:11–7. doi: 10.1016/j.bbi.2020.03.028
28. Shanafelt T, Ripp J, Trockel M. Understanding and addressing sources of anxiety among health care professionals during the COVID-19 pandemic. *JAMA*. (2020) 323:2133–4. doi: 10.1001/jama.2020.5893
29. Zhang Z. Model building strategy for logistic regression: purposeful selection. *Ann Transl Med*. (2016) 4:111. doi: 10.21037/atm.2016.02.15
30. Duong KNC, Le Bao TN, Nguyen PTL, Van TV, Lam TP, Gia AP, et al. Psychological impacts of COVID-19 during the first nationwide lockdown in Vietnam: web-based, cross-sectional survey study. *JMIR Form Res*. (2020) 4:e24776. doi: 10.2196/24776
31. Batra K, Singh TP, Sharma M, Batra R, Schvaneveldt N. Investigating the psychological impact of COVID-19 among healthcare workers: a meta-analysis. *Int J Environ Res Public Health*. (2020) 17:9096. doi: 10.3390/ijerph17239096
32. Alshekaili M, Hassan W, Al Said N, Al Sulaimani F, Jayapal SK, Al-Mawali A, et al. Factors associated with mental health outcomes across healthcare settings in Oman during COVID-19: frontline versus non-frontline healthcare workers. *BMJ Open*. (2020) 10:e042030. doi: 10.1136/bmjopen-2020-042030
33. De Girolamo G, Cerveri G, Clerici M, Monzani E, Spinogatti F, Starace F, et al. Mental health in the coronavirus disease 2019 emergency—the Italian response. *JAMA psychiatr*. (2020) 77:974–6. doi: 10.1001/jamapsychiatry.2020.1276
34. Liu H, Chen S, Liu M, Nie H, Lu H. Comorbid chronic diseases are strongly correlated with disease severity among COVID-19 patients: a systematic review and meta-analysis. *Aging Dis*. (2020) 11:668. doi: 10.14336/AD.2020.0502
35. Tamang N, Rai P, Dhungana S, Sherchan B, Shah B, Pyakurel P, et al. COVID-19: a National Survey on perceived level of knowledge, attitude and practice among frontline healthcare Workers in Nepal. *BMC Public Health*. (2020) 20:1–10. doi: 10.1186/s12889-020-10025-8
36. Erfani A, Shahriarirad R, Ranjbar K, Mirahmadizadeh A, Moghadami M. Knowledge, attitude and practice toward the novel coronavirus (COVID-19) outbreak: a population-based survey in Iran. *Bull World Health Organ*. (2020) 30. Available online at: https://www.who.int/bulletin/online_first/COVID-19/en/ (accessed February 2, 2021).
37. Zhong B-L, Luo W, Li H-M, Zhang Q-Q, Liu X-G, Li W-T, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *Int J Biol Sci*. (2020) 16:1745. doi: 10.7150/ijbs.45221
38. Tuoitre. *Medical Staff Worked Nearly 4 Extra Hours per Day During COVID-19 Epidemic*. Tuoitre (2020) [cited 2021 February 1]. Available online at: https://tuoitre.vn/nhan-vien-y-te-lam-viec-them-gan-4-gio-moi-ngay-trong-dich-covid-19-20200528065443519.htm (accessed February 1, 2021).
39. Rafiq D, Batool A, Bazaz M. Three months of COVID-19: a systematic review and meta-analysis. *Rev Med Virol*. (2020) 30:e2113. doi: 10.1002/rmv.2113
40. Zhu F-C, Guan X-H, Li Y-H, Huang J-Y, Jiang T, Hou L-H, et al. Immunogenicity and safety of a recombinant adenovirus type-5-vectored COVID-19 vaccine in healthy adults aged 18 years or older: a randomised, double-blind, placebo-controlled, phase 2 trial. *Lancet*. (2020) 396:479–88. doi: 10.1016/S0140-6736(20)31605-6
41. Wilkie DP, Orimoto TE, Miyamoto KDS, Stalk H-L, Mueller CW. Comorbidity of Psychiatric Disorders. In: *Levesque RJR, editor. Encyclopedia of Adolescence*. Cham: Springer International Publishing (2018). p. 709–16. doi: 10.1007/978-3-319-33228-4_198
42. Hanoitimes T. *Telehealth in Vietnam connects over 1,000 health centers*. The Hanoitimes (2020) [cited 2021 February 2]. Available online at: http://hanoitimes.vn/telehealth-in-vietnam-connects-over-1000-health-centers-314319.html (accessed February 2, 2021).

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Study on the Experience of Public Health System Construction in China's COVID-19 Prevention

*Pengfei Zhang**

School of Labor and Human Resources, Renmin University of China, Beijing, China

Background: China's experience in the process of COVID-19 prevention provides a reference for other countries in the world. This article studied the experience of public health system construction in China's COVID-19 prevention.

Methods: Based on literature review and theoretical analysis, this paper constructs a theoretical framework of national public health system construction in health crisis. Based on this theoretical framework, combined with the policies and measures formulated by the Chinese government in the process of COVID-19 prevention, this article evaluate the advantages and deficiencies of China's public health system construction in response to COVID-19.

Results: The Chinese government ensured the adequate supply of health resources, improved people's ability to pay medical expenses, and adopted advanced public health propaganda methods based on the Internet to help people grasp the basic information and development trend of COVID-19 in the process of COVID-19 prevention. At the same time, the utilization efficiency of health resources was low in China, people's ability to pay for medical expenses was unequal, and the disclosure of virus information in the early stage of the outbreak of COVID-19 is not timely.

Conclusions: Other countries can learn from the advantages of China's public health system construction and avoid China's deficiencies in the process of public health system construction, which will help them improve the efficiency of COVID-19 prevention.

Keywords: public health system construction, COVID-19, prevention, experience, China

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Mariela Deliverska,
Medical University Sofia, Bulgaria

***Correspondence:**
Pengfei Zhang
pfzoffice@ruc.edu.cn

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INTRODUCTION

COVID-19 appeared in Wuhan, China in December 2019. Just 1 month later, COVID-19 appeared in other countries in the world. Compared with the previously discovered coronaviruses, COVID-19 has outstanding characteristics, which brings new challenges to the public health system construction of various countries in the world. First of all, COVID-19 is highly contagious, which makes it rapidly spread to most countries in the world (1). When most countries find signs of COVID-19, there is often a large area of COVID-19 infection, which makes the public health system construction in most countries difficult to respond to the development of COVID-19 in time. Second, the strong infectivity of COVID-19 causes many people to be infected, which leads to the shortage of health resources for the treatment of COVID-19 (2, 3). Especially for underdeveloped countries, unsound medical technology prevents the infected people from getting

timely and effective treatment, which increases the risk of death. Third, COVID-19 has strong variability, and the infectivity and mortality of the mutated virus may be greatly improved, which may cause the process of public health system construction in response to the COVID-19 is long (4, 5). COVID-19 has brought serious harm to world economic development and social stability. For example, in the face of the impact of COVID-19, some countries have to restrict population mobility and shut down some living facilities and work departments, which in turn affect people's lives and incomes, and even exacerbates poverty (6, 7).

Public health system construction plays an important role in the process of COVID-19 prevention. Especially for developing countries and underdeveloped countries, public health system construction in response to COVID-19 can help them reduce the infection rate of COVID-19 and improve the prevention efficiency of COVID-19 (8, 9). As the most populous country in the world, China's experience in the process of COVID-19 prevention provides a reference for other countries in the world. China's public health system construction is a huge project. Especially in the face of the sudden COVID-19, it is a huge challenge to protect the medical demand of more than 1.4 billion people. Moreover, the scale of population mobility in China is huge. Facing the strong infectivity of COVID-19, the huge scale of population mobility undoubtedly aggravates the risk of cross infection of the virus. In addition, 1.4 billion people need a lot of health resources in the process of COVID-19 prevention, and ensuring people's access to medical services is also a major problem in public health system construction in China. In fact, with such a large population, China has controlled the large-scale spread of COVID-19 to a certain extent through public health system construction in the process of prevention. Moreover, in the process of COVID-19 prevention, China has ensured that people infected with COVID-19 can receive timely treatment through public health system construction. In addition, there are also some problems in the process of public health system construction in China. These problems also have certain reference value for other countries, which can help other countries avoid repeating the same mistakes in the process of public health system construction in response to COVID-19. This article studied the experience of public health system construction in China's COVID-19 prevention.

METHODS

This article adopts a qualitative design. Based on literature review and theoretical analysis, this paper constructs a theoretical framework of national public health system construction in health crisis. Based on this theoretical framework, combined with the policies and measures formulated by the Chinese government in the process of COVID-19 prevention, this article evaluate the advantages and deficiencies of China's public health system construction in response to COVID-19.

For any country, the purpose of public health system construction is to protect people's health. The emergence of health crises brings both physical and psychological effects to people. Different from ordinary diseases, diseases that trigger health crises often have higher infectious and mortality rates (10, 11). Once people are infected by a disease that triggers a health crisis, their demand for health resources is often several times higher than usual (12, 13). In a peaceful period without health crises, the supply of health resources can basically maintain people's normal demand. However, in the period of health crisis, health resources are often in short supply. There are two reasons for the shortage of health resources during the health crisis. On the one hand, people's demand for health resources rose sharply during the health crisis, which broke the balance of supply and demand of health resources in the original peaceful period without health crises. For example, with the spread of health crisis, the number of infected people is gradually increasing, and the corresponding demand for health resources is also gradually rising (14). Moreover, the psychological panic caused by the health crisis will also lead people to ease their worries by increasing the reserve of health resources, which will also cause an unreasonable increase in the demand for health resources (15). On the other hand, in order to control the spread of the health crisis, the government is forced to formulate measures to curb population mobility, and a large part of which involves the closure of the production sectors. The closure of production sectors will hinder the production of health resources and lead to insufficient supply (16, 17). Therefore, a country's public health system construction must ensure adequate health resources during the COVID-19 prevention.

The health crisis will also cause a decline in people's ability to bear medical expenses (18, 19). The decline in the ability to pay for medical expenses makes it difficult for people to maintain their health. Especially for the poor, their ability to pay for medical expenses in peaceful period without health crises is inherently low. The occurrence of a health crisis makes it difficult for them to afford the cost of maintaining health, and they are ultimately forced to give up treatment (20, 21). This phenomenon is particularly common in developing countries and underdeveloped countries. There are two reasons for the decline of people's ability to pay medical expenses during health crisis. First, health resources become scarcer during the health crisis, leading to an increase in the price of health resources. During the health crisis, people's demand for health resources increased, breaking the balance of supply and demand of health resources in peaceful period without the health crisis. The demand for health resources was greater than the supply during the health crisis, leading to an increase in the price of health resources (22). Second, during the health crisis, the country's economic development will be affected, leading to a decline in people's income. For example, some countries are forced to adopt the method of closing work sectors to control the spread of the health crisis, which will inevitably affect people's income (23, 24). It can be seen that during the health crisis, the rise in the price of health resources and the decline in people's income lead to a decline in people's ability to pay for medical expenses. Therefore, a country's public health system construction must protect people's ability to pay for medical expenses during the COVID-19 prevention.

The harm of health crisis to people's psychology also deserves the attention of the public health system. The psychological harm

of health crisis to people is invisible, and once the psychological harm is formed, it is often difficult to cure completely. Therefore, the psychological harm caused by health crisis is more serious than the physical harm. The ways of health crisis to people's psychological harm mainly come from two aspects. On the one hand, the psychological harm comes from people's ignorance of the virus that causes health crisis (25, 26). Because health crisis is sudden and the virus causing health crisis is highly infectious, once the health crisis is disclosed to people, the virus usually has spread over a large area. From the health crisis being disclosed to people fully grasping the virus information, there is a vacuum period of people's cognition of the virus that causes the health crisis. This vacuum period will increase people's panic and anxiety, and then cause psychological problems. This is because the occurrence of health crisis increases the risk of people's living environment. In the vacuum period, if people do not grasp information about the virus, they will not be able to judge whether their environment is at risk, which will obviously increase people's unnecessary anxiety and tension. On the other hand, the psychological harm comes from unknown of the development trend of the health crisis (27, 28). Once a health crisis occurs in a country, it often takes a long time for the country to prevent it. Especially for the health crisis caused by the virus with strong variability, its development trend is often difficult to predict. The unpredictability of health crisis disturbs people's long-term planning for their future life and work, triggers people's worries, and easily leads to psychological harm. Therefore, a country's public health system construction must focus on alleviating the psychological harm of health crisis to people during the COVID-19 prevention.

Based on the above three dimensions of the public health system construction in the process of COVID-19 prevention, we evaluated the advantages and deficiencies of the China's experience combined with the policies and measures formulated by the Chinese government.

RESULTS

Adequate Supply of Health Resources and Inefficient Utilization of Health Resources

For China with 1.4 billion people, the amount of health resources consumed every day is huge. Especially after the outbreak of COVID-19, people's demand for health resources is several times higher than before. In the process of China's public health system construction, the Chinese government has fully considered the impact of possible health crises on the supply of health resources. The Chinese government has established a reserve system of health resources, which meets people's demand for health resources during the COVID-19 prevention. First of all, under the reserve system of health resources, the Chinese government has built a batch of health resources for preventing health crises through fiscal expenditure, involving hospitals, doctors, and medical equipment. After the emergence of COVID-19, these reserved health resources were quickly applied to the prevention work (29). Second, unlike other countries, the public health power of the Chinese government is relatively high, which can make the Chinese government spend more fiscal expenditure and human resources on the construction of temporary health resources in the process of COVID-19 prevention. For example, during the COVID-19 prevention, the Chinese government had spent a lot of fiscal expenditure and human resources to build temporary hospitals in the short term to ensure timely treatment of infected people (30). The technical level of doctors and the improvement level of medical facilities in these temporary hospitals are the same as those in normal hospitals. Furthermore, the higher public health power makes it easier for the Chinese government to regulate the regional mobility of health resources. During the spread of COVID-19, all regions in China can be divided into high-risk regions and low-risk regions. People in low-risk regions have relatively low demand for health resources, while people in high-risk regions have relatively high demand for health resources. Therefore, the remaining health resources in low-risk regions can be allocated to high-risk regions. The Chinese government ensures the adequate supply of health resources in high-risk regions through the allocation of health resources from low-risk regions to high-risk regions (31).

At the same time, the inefficient utilization of health resources is one of the important deficiencies of China's public health system construction during the COVID-19 prevention. COVID-19 caused people's panic, forcing people to start hoarding a lot of health resources. The amount of health resources that people actually hoard is far greater than their actual demand, resulting in the waste of health resources and reducing the utilization efficiency of health resources (32). Moreover, people's hoarding of health resources triggered by the panic makes those who really need health resources may not be able to meet the demand of health resources in time. In order to protect the demand of people who really need health resources, the Chinese government is forced to build more health resources than the actual demand, which causes the waste of financial expenditure and human resources to a certain extent (33). In addition, although the Chinese government allocates resources from low-risk regions to high-risk regions to meet the health resources demand of people in high-risk regions, rural regions with low levels of economic development still face the shortage of health resources (34). The technical level of doctors and the improvement level of medical facilities in rural regions are relatively low. Faced with the threat of COVID-19, it is difficult to effectively protect the health of residents in rural regions. Compared with rural regions, urban regions in China are rich in health resources, and even have a lot of surpluses of health resources. These surpluses of health resources are not allocated to rural regions in time, resulting in low utilization efficiency of health resources.

The Improvement of the Ability to Pay Medical Expenses and the Inequality of the Ability to Pay Medical Expenses

During the COVID-19 prevention, in order to improve people's ability to pay for medical expenses, the Chinese government strengthened the connection between medical insurance system and COVID-19 treatment in the process of the public health system construction. First, for people who are infected with

COVID-19, they can improve their ability to pay for medical expenses through the medical insurance system. Specifically, part of the medical expenses of people infected with COVID-19 are paid by the medical insurance fund in the process of treatment, and people only pay part of the medical expenses (35). Second, the Chinese government implements medical assistance measures for the poor. Medical assistance measures are part of the medical insurance system and mainly for the poor. When the poor are infected with COVID-19, because they can't afford the high expenses of treatment, the Chinese government helps them to pay most of the medical expenses through medical assistance measures (36). The support funds for medical assistance measures come from fiscal expenditure. In addition, the improvement of medical insurance on the ability to pay medical expenses of people infected with COVID-19 is not only reflects in the treatment, but also involves the reduction of medical insurance contributions. In China, the support fund of medical insurance system comes from people's contributions. During the COVID-19 prevention, the Chinese government has reduced people's medical insurance contributions, which can reduce people's economic pressure to a certain extent and improve people's ability to pay for medical expenses (37).

For the prevention of COVID-19, although the medical insurance system improved people's ability to pay for medical expenses in the process of China's public health system construction, a new deficiency also emerged. There are differences in the improvement of people's ability to pay for medical expenses by the medical insurance system, which causes inequality. China's medical insurance system is divided into different types of projects according to different groups of people (38). For employees in urban regions, they participate in the Basic Medical Insurance for Urban Employees (BMIUE). For non-employees in urban regions, they participate in the Basic Medical Insurance for Urban Residents (BMIUR). For the population in rural regions, they participate in the New Rural Cooperative Medical Insurance (NRCMI). These three types of projects pay different medical expenses for people infected with COVID-19. Among them, the BMIUE pays the highest medical expenses for people infected with COVID-19, and it has the best effect in improving people's ability to pay for medical expenses. While the NRCMI pays the lowest medical expenses for people infected with COVID-19, and its ability to improve people's ability to pay for medical expenses is the worse than the BMIUE and the BMIUR (39). Therefore, for people participating in the NRCMI, when they are infected by COVID-19, the difference of medical insurance types leads to their low ability to pay for medical expenses. Therefore, the inequality of the ability to pay medical expenses is caused by the imperfect design of the medical insurance system. This problem can only be solved by the reform of medical insurance system, not by people themselves, because the medical insurance types are divided according to urban regions and rural regions. In addition, the difference in the level of economic development increased the difference in the ability to pay for medical expenses between rural residents and urban residents. In the face of the COVID-19, rural residents and urban residents bear the same economic pressure on medical expenses. However, rural residents' low ability to pay for medical expenses makes them difficult to maintain health, and even forced to give up treatment.

Advanced Public Health Propaganda Methods and Untimely Information Disclosure

China is a country that pays special attention to information propaganda. As early as in the period of planned economy system, China explored various ways to propagate information to people. The reason why China pays attention to information propaganda is that China has a large population. In order to ensure that the central government's information is disseminated to most people, various propaganda methods must be explored. In the process of China's public health system construction, advanced propaganda methods were also fully used to propagate COVID-19 information. On the one hand, during the COVID-19 prevention, the Chinese government disseminated the development information of COVID-19 to people through the Internet based on information technology (40). Compared with traditional information propaganda methods, COVID-19 information propaganda methods based on the Internet can greatly reduce unnecessary cross-infection, which is conducive to reducing the spread of COVID-19. On the other hand, in the process of deploying human resources and disclosing the specific preventive measures of COVID-19, the Chinese government also adopted information propaganda methods based on the Internet. The Chinese government formulated a series of COVID-19 prevention measures through Internet conferences and made the information public through the Internet, which saved a lot of time and improved the efficiency of COVID-19 prevention work (41). In addition, during the inspection of the population infected by COVID-19, medical institutions also spread basic information and detailed preventive measures of COVID-19 to the society through Internet, which enables people to regulate their own life behaviors and reduces the risk of being infected with COVID-19 (40). Through advanced public health propaganda methods based on the Internet, people can grasp the development trend of COVID-19, detailed basic information of COVID-19 and preventive measures, so as to reduce people's unknowns and worries about COVID-19, which is conducive to alleviating the psychological harm caused by COVID-19 to people.

Although China has advanced public health propaganda methods, the disclosure of the virus information in the early stage of the COVID-19 outbreak was not timely. The early stage of the COVID-19 outbreak is a key stage to control the spread of the virus. However, at this critical stage, the Chinese government did not take timely measures, and did not disclose COVID-19 information to the society in time. This deficiency of the public health system is fatal. Due to this deficiency, COVID-19 spread rapidly and eventually spread to all provinces in China. At the same time, people did not take any preventive measures against the spread of COVID-19 because they did not receive timely information disclosure. Untimely information disclosure caused the Chinese government's follow-up preventive measures to become passive, and more and more people were infected by COVID-19, which had a serious impact on people's

health (42). Moreover, untimely information disclosure increased people's panic about COVID-19 and brought psychological harm to people. Especially for employees, untimely information disclosure reduced the time for them to adjust their work plans, causing some employees to lose their work income and face the risk of falling into poverty (43). Furthermore, untimely information disclosure reduces people's trust in the Chinese government and public health system, which brings difficulties to the implementation of follow-up COVID-19 prevention work. For example, in the process of COVID-19 prevention, untimely information disclosure made some people hold a negative attitude toward the preventive measures formulated by the Chinese government, which hindered people from cooperating with the Chinese government.

DISCUSSION

Based on the theoretical framework of national public health system construction in health crisis and combined with the policies and measures formulated by the Chinese government in the process of COVID-19 prevention, this article studied the advantages and deficiencies of China's public health system construction in response to COVID-19. The study found that the Chinese government ensured the adequate supply of health resources, improved people's ability to pay medical expenses, and adopted advanced public health propaganda methods based on the Internet to help people grasp the basic information and development trend of COVID-19 in the process of COVID-19 prevention. These advantages of China's public health system construction meet people's medical demand to a certain extent, improve people's access to medical services, and increase people's awareness of COVID-19 prevention. However, there were still deficiencies in the process of COVID-19 prevention. The study found that the utilization efficiency of health resources was low in China, people's ability to pay for medical expenses was unequal, and the disclosure of virus information in the early stage of the outbreak of COVID-19 is not timely. These deficiencies brought serious challenges to China's COVID-19 prevention. The utilization efficiency of health resources caused a serious waste of health resources and made the Chinese government forced to invest a lot of financial funds for the construction of health resources, resulting in a waste of financial funds. People's unequal ability to pay for medical expenses originated from the defect of medical insurance system, which exacerbated the opposition of different groups. Especially for urban residents and rural residents, they participated in two different projects in the process of COVID-19 prevention, which made it difficult for rural residents to effectively protect their health. Untimely information disclosure in the early stage of the outbreak of COVID-19 was fatal for both the COVID-19 prevention and the social order. Untimely information disclosure accelerated the spread of COVID-19, which led to the development of COVID-19 from some regions to all provinces in China.

In response to COVID-19, China's public health construction should focus on improving the utilization efficiency of health resources. On the one hand, the allocation of healthy resources should depend on the population size of the region, rather than the level of economic development of the region. Health is the basic demand of people, and the amount of health resources should be related to the population size, not to the level of economic development. Especially for rural areas, the Chinese government should promote the mobility of health resources from cities to rural areas, and improve the infrastructure health facilities in rural areas, which is conducive to improving the health level of rural residents and improving the utilization efficiency of health resources. On the other hand, the allocation of health resources should depend on the development trend of COVID-19. People in high-risk areas have high demand for health resources, while people in low-risk areas have low demand for health resources. The Chinese government should promote the mobility of health resources from low-risk areas to high-risk areas. In high-risk areas, it is necessary for the Chinese government to correctly guide people's demand of health resources, and promote people to use health resources rationally, instead of excessively hoarding health resources.

The Chinese government should reform the medical insurance system to reduce the difference between urban residents and rural residents in their ability to pay for medical expenses, which is conducive to enhancing the rural residents' access to medical services in the process of prevention of COVID-19. Because the level of economic development in rural areas is lower than that in urban areas, and the income level of rural residents is significantly lower than that of urban residents, the ability of rural residents to pay for medical expenses is lower than that of urban residents. However, this gap has not been solved through the medical insurance system, but has been further expanded by the medical insurance system. Whether people are urban residents or rural residents, the medical expenses for treatment after being infected by COVID-19 will not vary with their status. Therefore, only by reforming the medical insurance system and strengthening the protection of rural residents' medical demand, can the Chinese government effectively solve the problem of rural residents' low ability to pay for medical expenses.

Moreover, the Chinese government should ensure that COVID-19 information can be disclosed to the public in time. Virus information cannot be concealed, and it will eventually be discovered by the public in a spreading way. In the early stage of the COVID-19 outbreak, untimely information disclosure not only exposed people to the virus, but also aggravated the spread of the virus. The Chinese government should learn from this deficiency. In addition, the Chinese government should improve the efficiency of virus detection, so that the virus can be detected in time at the early stage of virus development. High efficiency of virus detection can help the government formulate timely preventive measures, which is conducive to significantly controlling the spread of the virus.

CONCLUSION

Through the study on the experience of public health system construction in China's COVID-19 prevention, this article analyzed the advantages and deficiencies of China's public health system construction in response to COVID-19. This study has important reference value for other countries in the world by analyzing the COVID-19 prevention experience of China. Other

countries should ensure people's health demand through the adequate supply of health resources, ensure people's access to medical services by improving people's ability to pay for medical expenses, and raise people's awareness of COVID-19 by adopting advanced public health propaganda methods. At the same time, they should avoid the deficiencies in the process of China's public health system construction. During the COVID-19 prevention, they should avoid the phenomenon of inefficient utilization of health resources, promote equality in people's ability to pay for medical expenses, and disclose the development trend of COVID-19 to people in time, which will help them improve the efficiency of COVID-19 prevention.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/Supplementary Materials, further inquiries can be directed to the corresponding author.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Committee at Renmin University of China. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

PZ designs the study and drafted the manuscript.

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REFERENCES

1. Hatefi S, Smith F, Abou-El-Hossein K, Alizargar J. COVID-19 in South Africa: lockdown strategy and its effects on public health and other contagious diseases. *Public Health*. (2020) 185:159–60. doi: 10.1016/j.puhe.2020.06.033
2. Diptyanusa A, Zablon KN. Addressing budget reduction and reallocation on health-related resources during COVID-19 pandemic in malaria-endemic countries. *Malar J*. (2020) 19:411. doi: 10.1186/s12936-020-03488-y
3. Apriceno M, Lytle A, Monahan C, Macdonald J, Levy SR. Prioritizing health care and employment resources during COVID-19: roles of benevolent and hostile ageism. *Gerontologist*. (2021) 61:98–102. doi: 10.1093/geront/gnaa165
4. Hadied MO, Patel PY, Cormier P, Poyiadji N, Salman M, Klochko C, et al. Interobserver and intraobserver variability in the CT assessment of COVID-19 based on RSNA consensus classification categories. *Acad Radiol*. (2020) 27:1499–506. doi: 10.1016/j.acra.2020.08.038
5. Benetti E, Tita R, Spiga O, Ciolfi A, Birolo G, Bruselles A, et al. ACE2 gene variants may underlie interindividual variability and susceptibility to COVID-19 in the Italian population. *Eur J Hum Genet*. (2020) 28:1602–14. doi: 10.1038/s41431-020-0691-z
6. Pereira M, Oliveira AM. Poverty and food insecurity may increase as the threat of COVID-19 spreads. *Public Health Nutr*. (2020) 23:3236–40. doi: 10.1017/S1368980020003493
7. Sliwa K, Yacoub M. Catalysing the response to NCDI Poverty at a time of COVID-19. *Lancet*. (2020) 396:941–3. doi: 10.1016/S0140-6736(20)31911-5
8. Dixon BE, Caine VA, Halverson PK. Deficient response to COVID-19 makes the case for evolving the public health system. *Am J Prev Med*. (2020) 59:887–91. doi: 10.1016/j.amepre.2020.07.024
9. Carter P, Anderson M, Mossialos E. Health system, public health, and economic implications of managing COVID-19 from a cardiovascular perspective. *Eur Heart J*. (2020) 41:2516–8. doi: 10.1093/eurheartj/ehaa342
10. Filippidis FT, Gerovasili V, Man WD, Quint JK. Trends in mortality from respiratory system diseases in Greece during the financial crisis. *Eur Respir J*. (2016) 48:1487–9. doi: 10.1183/13993003.01232-2016
11. Ilic M, Ilic I. Gender disparities in mortality from infectious diseases in Serbia, 1991-2014: a time of civil wars and global crisis. *Epidemiol Infect*. (2016) 144:2473–84. doi: 10.1017/S0950268816001345
12. Callahan D. What is a reasonable demand on health care resources? Designing a basic package of benefits. *J Contemp Health Law Policy*. (1992) 8:1–12.
13. Wu Y. China's health care sector in transition: resources, demand and reforms. *Health Policy*. (1997) 39:137–52. doi: 10.1016/S0168-8510(96)00869-X
14. Pagaiya N, Phanthunane P, Bamrung A, Noree T, Kongweerakul K. Forecasting imbalances of human resources for health in the Thailand health service system: application of a health demand method. *Hum Resour Health*. (2019) 17:4. doi: 10.1186/s12960-018-0336-2
15. Blundell R, Windmeijer F. Identifying demand for health resources using waiting times information. *Health Econ*. (2000) 9:465–74. doi: 10.1002/1099-1050(200009)9:6<465::aid-hec525>3.0.co;2-h
16. Zhou M, Oakes AH, Bridges JFP, Padula WV, Segal JB. Regional supply of medical resources and systemic overuse of health care among medicare beneficiaries. *J Gen Intern Med*. (2018) 33:2127–31. doi: 10.1007/s11606-018-4638-9
17. Basu K, Pak M. Will the needs-based planning of health human resources currently undertaken in several countries lead to excess supply and inefficiency? *Health Econ*. (2016) 25:101–10. doi: 10.1002/hec.3125
18. Wu J, Davis-Ajami ML, Kevin Lu Z. Impact of depression on health and medical care utilization and expenses in US adults with migraine: a retrospective cross sectional study. *Headache*. (2016) 56:1147–60. doi: 10.1111/head.12871
19. Davis-Ajami ML, Lu ZK, Wu J. Multiple chronic conditions and associated health care expenses in US adults with cancer: a 2010-2015 medical expenditure panel survey study. *BMC Health Serv Res*. (2019) 19:981. doi: 10.1186/s12913-019-4827-1
20. Liu X, Zhang Q, Xu Y, Wu X, Wang X. Trend analysis of medical expenses in Shenzhen after China's new health-care reforms. *Int J Health Plann Manage*. (2020) 35:760–72. doi: 10.1002/hpm.2951
21. Tobe M, Stickley A, del Rosario RB Jr., Shibuya K. Out-of-pocket medical expenses for inpatient care among beneficiaries of the National Health Insurance Program in the Philippines. *Health Policy Plan*. (2013) 28:536–48. doi: 10.1093/heapol/czs092
22. Hioki A. Relationship of health services to medical expenses for the national health insurance and certification rate for long-term care insurance services in municipalities. *J Epidemiol*. (2002) 12:136–42. doi: 10.2188/jea.12.136
23. Coetzee BJ, Kagee A. Structural barriers to adhering to health behaviours in the context of the COVID-19 crisis: considerations for low- and middle-income countries. *Glob Public Health*. (2020) 15:1093–102. doi: 10.1080/17441692.2020.1779331
24. Das A. The asthma crisis in low-income communities of color: using the law as a tool for promoting public health. *Rev Law Soc Change*. (2007) 31:273–314.
25. De Pelichy GE, Verloo H, Gasser J, Monod S. Interests and need for strengthening home care in the context of psychological crisis situations—the result of a strong public health policy. *Rev Med Suisse*. (2020) 16:1741–4.
26. Mukherjee D, Saxon V. "Psychological Boarding" and community-based behavioral health crisis stabilization. *Community Ment Health J*. (2019) 55:375–84. doi: 10.1007/s10597-018-0237-9
27. Yuen KF, Wang X, Ma F, Li KX. The psychological causes of panic buying following a health crisis. *Int J Environ Res Public Health*. (2020) 17:3513. doi: 10.3390/ijerph17103513

28. Mukhtar S. Mental health and psychosocial aspects of coronavirus outbreak in Pakistan: psychological intervention for public mental health crisis. *Asian J Psychiatr*. (2020) 51:102069. doi: 10.1016/j.ajp.2020.102069
29. Pan SL, Cui M, Qian J. Information resource orchestration during the COVID-19 pandemic: a study of community lockdowns in China. *Int J Inf Manage*. (2020) 54:102143. doi: 10.1016/j.ijinfomgt.2020.102143
30. Xinhua. *The Central Guidance Group Went to Hubei to Inspect the Huoshenshan Hospital*'(2020). Available online at: http://www.gov.cn/guowuyuan/2020-02/03/content_5474082.htm (accessed February 3, 2020).
31. Council S. Mobilize All Forces to Improve the Production and Supply Capacity of Key Medical Materials (2020). Available online at: http://www.scio.gov.cn/xwfbh/xwbfbh/wqfbh/42311/43082/zy43086/Document/1680729/1680729.htm (accessed May 20, 2020).
32. Li Q, Wei J, Jiang F, Zhou G, Jiang R, Chen M, et al. Equity and efficiency of health care resource allocation in Jiangsu Province, China. *Int J Equity Health*. (2020) 19:211. doi: 10.1186/s12939-020-01320-2
33. Li D, Chao J, Kong J, Cao G, Lv M, Zhang M. The efficiency analysis and spatial implications of health information technology: a regional exploratory study in China. *Health Informatics J*. (2020) 26:1700–13. doi: 10.1177/1460458219889794
34. Luo Y, Yao L, Hu L, Zhou L, Yuan F, Zhong X. Urban and rural disparities of personal health behaviors and the influencing factors during the COVID-19 outbreak in China: based on an extended IMB model. *Disaster Med Public Health Prep*. (2020) 14:1–5. doi: 10.1017/dmp.2020.457
35. Xia Y, Li S, Meng K. The impact of the COVID-19 on the insurance industry in China. *Front Econ Manag*. (2020) 1:28. doi: 10.3390/ijerph17165766
36. Daily E. *New Coronary Pneumonia Treatment Costs and Medical Insurance are Reimbursed in Accordance with Regulations* (2020). Available online at: http://www.gov.cn/xinwen/2020-04/12/content_5501508.htm (accessed April 12, 2020).
37. Taxation S. *Guidelines on Preferential Tax Policies for Response to the New Coronary Pneumonia Epidemic* (2020). Available online at: http://www.gov.cn/xinwen/2020-03/10/content_5489528.htm (accessed March 10, 2020).
38. Ma C, Zhang Y, Li Y, Wang Y, Jiang Y, Wang X, et al. Healthcare, insurance, and medical expenditure of the floating population in Beijing, China. *Front Public Health*. (2020) 8:375. doi: 10.3389/fpubh.2020.00375
39. Sun JY. Welfare consequences of access to health insurance for rural households: evidence from the New Cooperative Medical Scheme in China. *Health Econ*. (2020) 29:337–52. doi: 10.1002/hec.3985
40. Xinhua. *Internet Hospital's New Coronary Pneumonia Diagnosis and Treatment Service Platform* (2020). Available online at: http://www.gov.cn/xinwen/2020-02/14/content_5478820.htm (accessed February 14, 2020).
41. He D, Gu Y, Shi Y, Wang M, Lou Z, Jin C. COVID-19 in China: the role and activities of Internet-based healthcare platforms. *Glob Health Med*. (2020) 2:89–95. doi: 10.35772/ghm.2020.01017
42. Hu G, Li P, Yuan C, Tao C, Wen H, Liu Q, et al. Information disclosure during the COVID-19 epidemic in China: city-level observational study. *J Med Internet Res*. (2020) 22:e19572. doi: 10.2196/19572
43. Xu T, Sattar U. Conceptualizing COVID-19 and public panic with the moderating role of media use and uncertainty in China: an empirical framework. *Healthcare (Basel)*. (2020) 8:249. doi: 10.3390/healthcare8030249

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COVID-19 Pandemic—Frontline Experiences and Lessons Learned From a Tertiary Care Teaching Hospital at a Suburban Location of Southeastern India

*V. Nirmal Coumare[1], Swati Jayant Pawar[1], P. S. Manoharan[2], R. Pajanivel[1], Lokesh Shanmugam[1], Hemanth Kumar[1], Abhijit V. Boratne[1], Balanehru Subramanian[3], Joshy M. Easow[1], B. Sivaprakash[1], R. Kalaivani[1], K. Renuka[4], S. Prabavathy[4], Kripa Angeline[4], Agieshkumar Balakrishna Pillai[3] and S. R. Rao[5]**

[1] Mahatma Gandhi Medical College and Research Institute, Sri Balaji Vidyapeeth (Deemed to Be University), Puducherry, India, [2] Indira Gandhi Institute of Dental Sciences, Sri Balaji Vidyapeeth (Deemed to Be University), Puducherry, India, [3] Central Inter-disciplinary Research Facility, Sri Balaji Vidyapeeth (Deemed to Be University), Puducherry, India, [4] Kasturba Gandhi Nursing College, Sri Balaji Vidyapeeth (Deemed to Be University), Puducherry, India, [5] Research, Innovation and Development, Sri Balaji Vidyapeeth (Deemed to Be University), Puducherry, India

The key challenges to any health care setup during emergency situations, such as that of the COVID-19 pandemic would be to rapidly address hospital preparedness and response tailored to the local population, societal influences, political factors within the existing infrastructure, and workforce. Second, to adopt and moderate policies, standard operating procedures (SOPs) and guidelines issued by national and international agencies, such as WHO, CDC, and the Indian Council for Medical Research (ICMR) were tailor-made to the local conditions of the hospital and community. In this publication, we have discussed the challenges and experiences in preparation and responses to the ongoing COVID-19 pandemic at a tertiary teaching hospital situated at a suburban locale in a small union territory. Puducherry is located in the South Eastern Coromandel Coast of India. The core processes, such as hospital preparedness, adoption, and amendments to SOPs based on dynamic changes in guidelines released by the central and local government, training given to health care workers, setting up the in-house diagnostic facility, surge capacity, management of supplies during the lockdown, infection prevention, and control and patient care are discussed. We have also reinforced our experiences in translating COVID-related opportunities for research and innovation in the form of awards and research proposals for the faculty and students of our institute. The lessons learned in terms of strength and limitations on the ground level of public health during this process is worth sharing as it would provide guidance in preparing the health care setups for pre- and post-pandemic.

Keywords: COVID-19, public health, health research service, health care setting, health care policies

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Jongnam Hwang,
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Janis Kay Jansz,
Curtin University, Australia
Nina Musurlieva,
Plovdiv Medical University, Bulgaria

****Correspondence:***
S. R. Rao
vp@sbvu.ac.in

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HIGHLIGHTS

- Every hospital, be it in an urban or a suburban location, needs to be prepared for any kind of unforeseen pandemic.
- A vigilant Hospital Emergency Committee consistently monitors the existing infection control practices and is also prepared for any pandemic situations, such as these.
- The Hospital Response Team makes and enforces "protocols" in line with the directions of the local and central government bodies.
- Preparedness of the hospital is essential in the transformation of the existing infrastructure and capacity for changing situations without affecting normal patient care.
- Financial contingency in the initial stage is only temporary. The returns at the latter stage would replenish the loss at the earlier stages.
- Hospitals should be kept abreast with various coping strategies of other health care setups and learn from shared experiences of others.

FIGURE 1 | Geographic location of Puducherry and location of MGMCRI hospital in the outskirts of the small town Puducherry. Other affiliated Institutes of Sri Balaji Vidyapeeth–Sri Sathya Sai Medical College and Research Institute, Indira Gandhi Institute of Dental Sciences. Bed capacity 1,400, 15 modular operation theaters. Patient flow 1,000 out-patients 700 inpatients per day.

INTRODUCTION

The COVID-19 pandemic continues to bring in new challenges every day to millions of people across the globe, in terms of providing health care, social obligation, economy, and mental health. Human coronavirus is known to humans earlier in various different forms, such as 229 E, OC43, NL63, HKU1, SARS-CoV, and MERS-CoV. The present form of novel coronavirus (COVID-19) originated from Wuhan, Hubei province of China, and spread to other parts of the world. Western pacific countries like Australia, New Zealand, Brunei Darussalam, Japan, and Singapore showed an early record of cases in January 2020 (1, 2). By the end of January 2020, the World Health Organization (WHO) declared COVID-19 as a "public emergency of International Concern" (3, 4). America and European and East Mediterranean countries by the end of February 2020 showed the first reports of COVID cases. Southeastern countries showed up the first report of cases from March 2020. Africa reported its first case by the end of March 2020. India was not among the worst-hit countries till May 2020, but by the end of 2020, the country ranked top in the number of cases in Asian countries (5). Lockdown efforts by the Indian government was appreciated by WHO and other countries as it "contained" the spread of infection in the initial stages. The efforts were mentioned as "robust and comprehensive," although it may seem "aggressive." Subsequent phases of lockdown did not show much impact on the containment of cases. With the second-highest population in the world, India, despite its rapid increase in numbers, is showing a very mild reduction of mortality (0.89%) and active cases (1.1%) as of October 2020 (5). India is a federal union comprising 28 states and eight union territories, for a total of 36 entities. Among all the Indian States, the largest and most well-developed states of this subcontinent—Maharashtra and Tamil Nadu—showed a rapid increase in the number of new cases, which was a matter of concern. This kind of surge is in spite of the availability of good hospital services from both the government and private sectors in these states. By October 2020, all the lockdown measures were lifted before the curve reached the plateau (6).

During the initial phase of the pandemic, many countries developed policies, standard operating procedures (SOPs), and guidelines at the national level [including the Indian Council for Medical Research (ICMR), Ministry of Health and Family Welfare, Government of India] (7) based on those issued by international public health agencies, such as WHO (8) and Centers for Disease Control and Prevention (CDC) (9) USA. Later, however, because of the rapid spread of COVID-19 in a shorter time frame and the lack of prior knowledge and available evidence on the risk of transmission, morbidity, and mortality (10), developers of guidelines were challenged to appropriate the SOPs suited to local and regional situations. Conflicting recommendations by various agencies, such as the case of wearing a mask between CDC and WHO, and a difference in opinion as to when it is safe to discharge COVID-19 cases from the hospital or end home isolation, etc. also added to the confusion. Given the dynamic nature of the problem and accumulated evidence over a period, the guidelines have been modified to ensure a reduction in the disease incidence. Therefore, the key challenges to any health care setup during emergencies, such as that of the COVID-19 pandemic would be to adopt and moderate various instructions issued by national and international agencies that are conflicting and changing from time to time to suit the needs of local community and resources. **Figure 1** summarizes various factors and linkages to consider in preparing the health care setup before and during pandemic for adopting and preparing guidelines.

The Indian health care system is organized into primary, secondary, and tertiary levels. At the primary level are sub-centers and primary health centers (PHCs). At the secondary level, there are community health centers (CHCs) and smaller

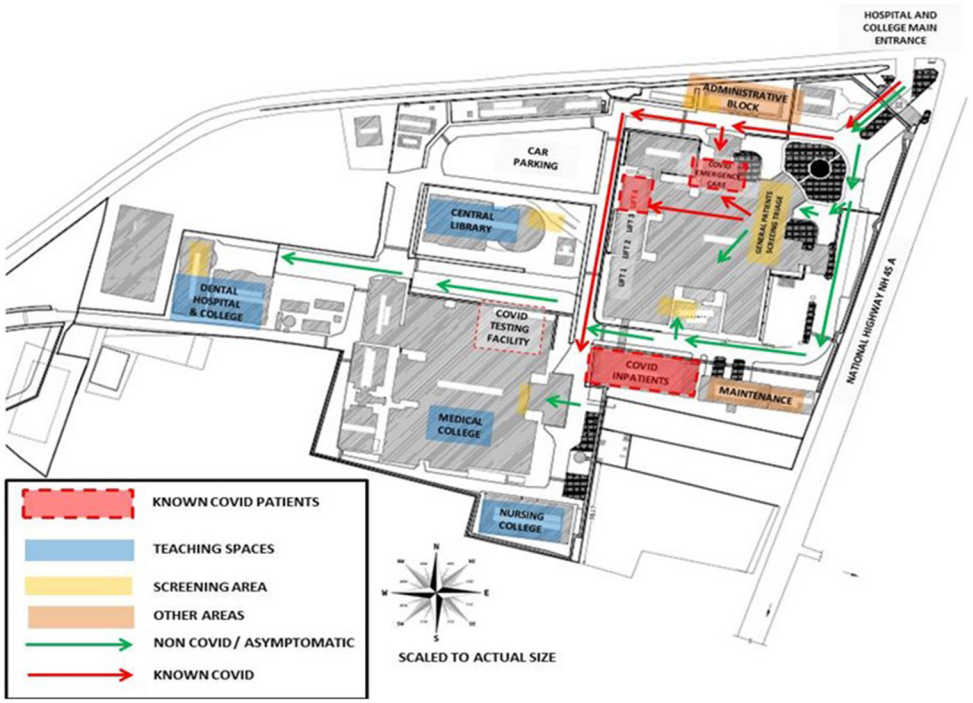

FIGURE 2 | Hospital campus showing a planned identification of COVID care facilities, screening points, high risk zone, and other safe zones.

sub-district hospitals. Finally, the top level of public care provided by the government is the tertiary level, which consists of medical colleges and district/general hospitals. The number of PHCs, CHCs, sub-centers, and district hospitals has increased in the past 6 years, although not all of them are up to the standards set by Indian Public Health Standards (11).

Tertiary-level hospitals at medical colleges and district/general hospitals play a critical role in national and local responses to emergencies, such as communicable disease epidemics. These hospitals should be able to rapidly adopt various guidelines and address hospital preparedness and response for the pandemic tailored to the local population, societal influences, political factors within existing infrastructure, and workforce.

In this context, the present article describes frontline experiences and lessons learned from "Mahatma Gandhi Medical College and Research Institute" (MGMCRI), a tertiary care teaching hospital in the private sector in the suburban part of Southeastern India during the COVID-19 pandemic. MGMCRI is a teaching hospital and has the mandate of uninterrupted teaching and training to undergraduate, post-graduate, super-specialty students, and scholars. Furthermore, being a private teaching hospital does not receive any kind of external support in terms of finances even under pandemic-related emergencies for the treatment of patients. Despite being in a remote location, MGMCRI renders tertiary care in medical and dental services on a non-profit basis primarily to the rural population. The road, however, was never smooth and required continued attention to the safety of health care workers (HCWs) and doctors.

GEOGRAPHIC AND ETHNIC UNIQUENESS

MGMCRI is situated in Puducherry (a union territory in the coastal stretch of Tamil Nadu—a south Indian State). Puducherry by itself is made up of pockets of land scattered in the region of Tamil Nadu. Geographically, the hospital is situated at Pillayarkuppam, which is a part of a suburban village commune Bahour, which administratively belongs to Puducherry (**Figure 2**).

Each country and region vary in terms of capacity, health policies of the government, and health infrastructure. Puducherry recorded 2500 COVID-affected cases per 1,000,000 of the population, which ranks second in India (12). Being the "*health indicator*" of the country, with the lowest infant mortality rate, it was an irony for us to witness these alarming statistics. In a small town with nine hospitals that cater for tertiary care, private multispecialty hospitals, 17 disease-specific clinics, four community health centers, 39 primary health centers, 77 sub-centers, 14 ESI dispensaries, and rural and urban health centers, it was saddening to note the increase of cases. Preventive and curative programs for tuberculosis, leprosy, filaria, malaria, and blindness control program with free cataract surgeries have curbed major illnesses in this town. Furthermore, Pondicherry had never witnessed a viral flu outbreak or a pandemic of this magnitude before. Arthropod-borne viral diseases like dengue have taken their toll on a few thousands of the population, with a few outbreaks in the last two decades. None of the hospitals in this

region were prepared to handle the COVID disaster of such a magnitude.

With this background, the surge in COVID-19 infections can only be attributed mainly to the complacency and casual attitude of the public at large of this calm and peaceful town. In the initial phase, soon after Puducherry recorded its first case during the lockdown, the growth in a number of cases was well-contained. Pondicherry is a tourist destination for the neighboring states and also other countries, with its French legacy preserved in its French Quarter, with tree-lined streets, mustard-colored colonial villas, and chic boutiques and a seaside promenade running along the Bay of Bengal. Many tourists flood this small town on the weekends and vacations throughout the year. Therefore, the economy of this union territory depends on tourism. Lifting of lockdown and opening of borders to support the dwindling economy led to the surge of cases through migration of the "*floating population*." As a result, the COVID pandemic further crippled the so-called "*health hub*" of the Indian subcontinent.

Hospitals play a critical role within the health system in providing essential medical care to the community, particularly during the pandemic crisis. As discussed above, the COVID-19 pandemic is teaching new lessons to health care providers and policymakers to adopt national and international guidelines and policies to develop "*tailor-made system*" solutions at the micro-economy level, yet providing effective treatment taking into consideration disease patterns in that region, the lifestyle of the particular population, food habits, socioeconomic status, apprehensions of the society, political factors, local administrators' policies, hospital infrastructure, workforce available, financial structure, and community.

With regard to many accreditation cycles from various quality councils, few hospitals have managed to establish disaster response teams and infection control protocols in place (13). MGMCRI was recognized as a COVID care center and a diagnostic center, by the local government after the first few months of the outbreak in this region. Only one other private hospital was given the testing facility for the entire region. This hospital provides its medical services to the villages in Puducherry and also to many villages and cities from the neighboring state—Tamil Nadu.

EVOLUTION AS A COVID CARE CENTER

The hospital had to go through various milestones in the evolutionary process of being a COVID care center, such as:

a. Establishment of a Hospital Core COVID Committee (HCCC), which included members from clinical, human resources (HR), nursing, biomedical engineering, purchase, pharmacy, laundry, food and beverage, and transport departments. A contingency team of members was also formed.
b. Preparation of SOPs for various processes adopting and moderating WHO/ICMR guidelines.
c. Amendment of SOPs based on the dynamic change in the guidelines as and when released by the central and local government.
d. Intensive training for health care providers.
e. Setting up of an in-house COVID diagnostic facility.
f. Logistics to scale up facility space for critical care, isolation, cohort, the accessibility of mechanical ventilators, and the availability of other resources.
g. Wards to be reshuffled to accommodate COVID patients in an isolated facility.
h. Respond to government directives in community service and provision of free beds to the government for COVID care.

A well-functioning hospital incident management system is essential for the effective management of emergency operations. As MGMCRI is already recognized by national and international accreditation bodies like the National Accreditation Board for Testing & Calibration Laboratories (NABL), NABH, and ISO, the disaster response team and some of the fundamental protocols of disaster management, infection control, and risk mitigation were already in place. The continuity of essential health services, e.g., emergency services, urgent surgical operations, and maternal and child care, was ensured during the outbreak season. Some of the important functions of various departments and individuals during the operation are summarized below:

1. **Internal and External Communication of the Facility**

The HCCC has devoted one nodal person from whom authorized information and the decisions taken by the HCCC on the safety of patients, visitors, doctors, and staff and students, circulars or guidelines arising from the government related to COVID would be conveyed to the hospital staff from time to time. The committee's role is to consider all SOPs made by the Health Ministries of local and national governments issued from time to time and moderate their relevance, take decisions to moderate to the hospital ecosystem, and supervise for compliance. All SOPs (**Table 1**) were carefully made and had information on the following:

a. What functions does it affect?
b. What are the procedures that are derived from this policy?
c. Elements of the SOP workflow.
d. Who does it affect?
e. Who is responsible for its implementation?
f. How is the SOP communicated to the stakeholders?
g. Who needs to be educated on this SOP?
h. Who will do the education?
i. What is the media used for education?
j. Who will monitor the SOP?
k. How will the monitoring be done?
l. When will the revision be done?
m. Who has prepared this document? Contact details of the same.
n. Who has approved this document?

The SOPs were developed to handle COVID patients with mild, moderate, and severe symptoms. Flow charts were

TABLE 1 | List of standard operating protocols and policies.

S. No.	Name of the Policy/SOPs
1	Policy for Contact Tracing of COVID19—Positive Employees of Sri Balaji Vidyapeeth, Main Campus
2	Policy for in Campus Contact Tracing of COVID19 (Version 1.2)
3	Policy for Contact Tracing of COVID19—Positive Employees of Sri Balaji Vidyapeeth, Main Campus (Version 3)
4	Policy for COVID19 Screening to Post-Graduate Courses 2020–2027
5	Policy for SBV Healthcare Workers Tested Positive for COVID19
6	SOP for Low Risk Quarantine
7	SOP for High Risk Quarantine
8	SOP for Setting up Isolation Facility/Ward
9	SOP for Dental Clinical Protocols
10	SOP for Rational use of PPEs (Version 1)
11	SOP for COVID19 Management
12	SOP for Preventive Measure to Contain of COVID19 in Skill or Entrepreneurship Training Institutions and Higher Educational Institutes

developed and circulated as SOPs to all health care providers for uniformity and also.to prevent litigations in this unfamiliar zone (**3**–**5**).

The hospital also designated a Public Relation Officer (PRO) to manage the flow of information from the hospital to the government/local authority, press, media, etc. All the information was passed on a regular basis to the Integrated Disease Surveillance Project (IDSP). IDSP is an online reporting system under the Integrated Disease Surveillance Programme (IDSP) of the National Health Mission Programme headquartered at Ministry of Health and Family Welfare Government of India. The key objective of this program is to strengthen/maintain a decentralized laboratory-based IT-enabled disease surveillance system for epidemic-prone diseases to monitor disease trends and to detect and respond to outbreaks in the early phase through trained rapid response teams (RRTs). The HR head of each hospital in the country is involved in data entry of real-time information in IDSP and, at the same time, communicating related information to the staff and the frontline workers regarding quarantine rules and facilities specially set up by the hospital for meeting the emergencies from time to time.

Continuous education and training for health care professionals and workers in the frontline was provided to provide quality care with extreme precautions. The residents and post-graduates involved in COVID care were educated on the policies, protocols, and guidelines from various statutory bodies and the hospital.

2. Human Resource Activities

In a dynamic and unpredictable situation like this pandemic, human resource management is a challenging task. Ensuring adequate trained staff capacity and continuity of operations in response to increased demand is important while maintaining the identified essential services. Furthermore, the HR department is also responsible in addressing liability, insurance, salary, management of leave application, and approval to the best of their capacity. Appreciably, HR has devised duty rotations in such a way that the demands are met throughout the period without overcrowding, as well as the arrangements for their transport, lodging, and food without putting anyone at high risk. As there is an increase in the demand for housekeeping and maintenance staff during these times, the rotation postings were planned round the clock and as is called 24 × 7.

3. Tele-clinic Support

To facilitate regular support to the patients during different phases of lockdown, MGMCRI set up a special Tele-clinic facility. "*Easy to understand advisories*" in English and Tamil (the native language of the region) developed in consultation with clinicians and the Community Medicine department are transmitted through short messaging service (SMS) to alleviate fear and apprehension and to provide practical advice on common medical problems. This facility was highly successful for uninterrupted communication. Education and training on the management of the Tele-clinic facility in the hospital were provided to health care professionals. It can be also told that this hospital is the first in this region to care for the public through teleconsultation.

The hospital also became a partner to the technology-enabled remote monitoring and counseling platform for home-isolated COVID patients, which was also launched by the local government in partnership with Step One organization (the largest doctor volunteer group to fight COVID). The platform is based on the involvement of doctors and tele-counseling by nurses, psychologists, and social workers with sufficient training provided by the Step One organization. The purpose is to reduce the burden of public hospitals to treat high-risk cases and to optimize the health care workforce. The platform also aims to improve the physical and mental well-being of COVID patients quarantined at home. Faculty members and post-graduate students of Kasturba Gandhi Nursing College volunteered to participate in this platform and played an important role as counselors and provided counseling services. Tele-counseling was done through Fresh Desk Mobile App with services, such as telecommunication with the allotted home-isolated clients; daily identification of COVID symptoms and referral to hospitals; identifying the common psychological problems and providing counseling to the needed clients; and providing psychological support to home-isolated clients and explaining the do's and don'ts during pandemic.

4. Surge Capacity

Surge capacity is the ability to expand health services beyond their normal capacity to meet the increased demand for clinical care. COVID-19 cases increased rapidly, and there was an increase in demand for patient care and admissions over a prolonged period of time. Calculation of "*maximal case admission capacity*" is determined not only by the total number of beds but also by the availability of human resources, the

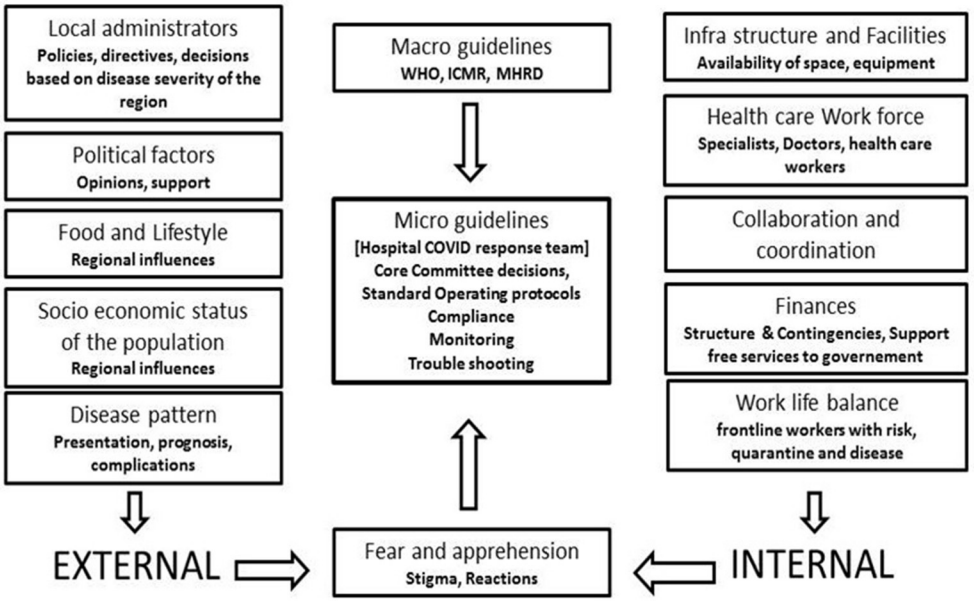

FIGURE 3 | External and internal influences on development of micro guidelines which decides the preparation of standard operating protocols and other decisions of the response.

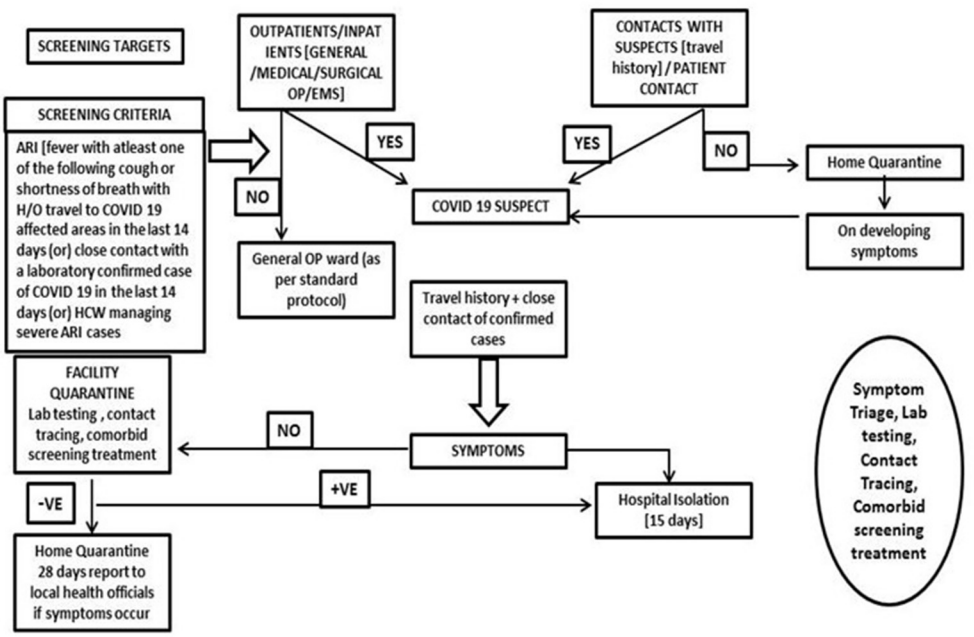

FIGURE 4 | General patient screening protocol: screening criteria and triage policy.

adaptability of facility space for critical care, isolation, cohort, the accessibility of mechanical ventilators, and the availability of other resources. The most important concern is having a medical space to create a new facility with reduced or no risk of COVID transmission. In other words, it meant creating a facility wherein HCWs are not at risk and the patients are attended to with caution. In this aspect, many of the tertiary care hospitals in Europe, Australia, and Asia (14–17) have published their experiences. An additional investment was recommended to the Kenyan government to enhance the surge capacity in terms of ICU and ventilated beds in hospitals (18). The triage system of evaluation and categorization of the patients was required for

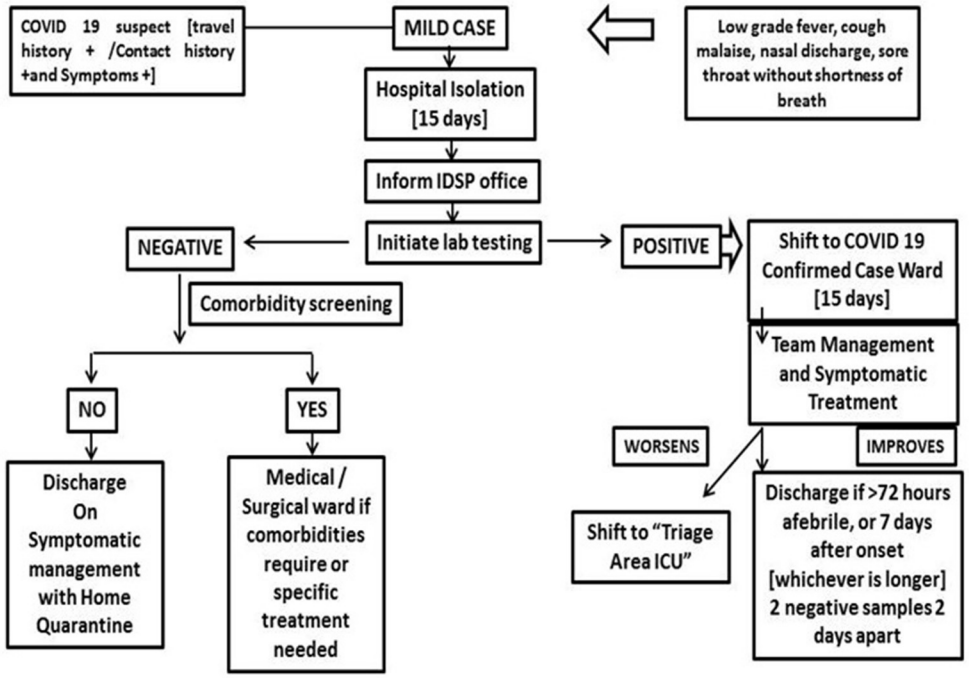

FIGURE 5 | Patient management for COVID suspects (mild case) with presenting symptoms.

optimal utilization of the resources for medical care of everyone at once. Thus, an efficient and accurate triage system and an in-patient management strategy were organized to ensure adequate treatment of COVID-19 acute respiratory infection. Based on the previous experience on MERS in 2015 in South Korea, health care facility-associated nosocomial route of infection was considered a potential source for COVID-19 transmission (19, 20). To address this, MGMCRI developed its own SOPs (**Figures 1**, **3**, **4**) of triaging patients by establishing flu clinics at the entrance and taking in the patients based on their symptoms, travel history, etc. So, the hospital earmarked various locations for mild to moderate cases, critically ill cases, and patients needing surgical/cath-lab procedures or deliveries and other asymptomatic patients coming from non-containment zones.

Due to the infectious nature of SARS-CoV-2, the number of patients with other regular ailments in both inpatient and outpatient wards has reduced drastically since the first week of April. This prompted us to shut down one floor completely and keep others operational for regular patients. Beds for various purposes, such as pre- and post-operative surgical care and general medicine and allied specialties were earmarked beds. So, a decision to escalate or de-escalate depended on the utilization of beds.

There was speculation that there could be a surge of patients after the lockdown was lifted; this is where there was a need to prepare for a surge to manage not just for the COVID cases but also for regular non-COVID patients who were unable to reach the hospital because of the lockdown. A very significant point is to adapt admission and discharge criteria and prioritize patients and clinical interventions according to available treatment capacity on demand.

Initial phases of lockdown had a total shutdown of all elective procedures in ophthalmology, otolaryngology, and dermatology. By April 2020, all procedures resumed including adequate infection control protocol and other safety precautions. The emergency ward took care of COVID patients who developed acute complications. The existing emergency ward was shifted to another place. An "*exclusive facility*" with 200 beds was created in the campus premises isolated from the other areas, by "*rearrangement of various facilities*" like the Center for Music Therapy Education and Research (CMTER), the Center for Yoga Therapy Education and Research (YTER), Internal Quality Assurance Cell (IQAC), Medical Informatics, and wards of dermatology and venereology, surgery, and ophthalmology. A 102-bed facility was also assigned in the medical hospital block for COVID patients, of which 20 beds were assigned to in-house employees who succumbed to the infection. Ten critical care beds and intensive care units with ventilator support system were dedicated to COVID-related emergencies. The general wards also accommodated patients with mild to moderate symptoms that were referred from government hospitals. Apart from the general ward, COVID care special wards were also made available. During the late phase, the hospital assigned 25% of its total capacity of 1400 beds to COVID care. The hospital has also prepared a plan to expand the bed capacity if the need arises. MGMCRI of Sri Balaji Vidyapeeth University was also recognized as one of the two COVID testing centers among the seven private hospitals at Puducherry from the month of June 2020.

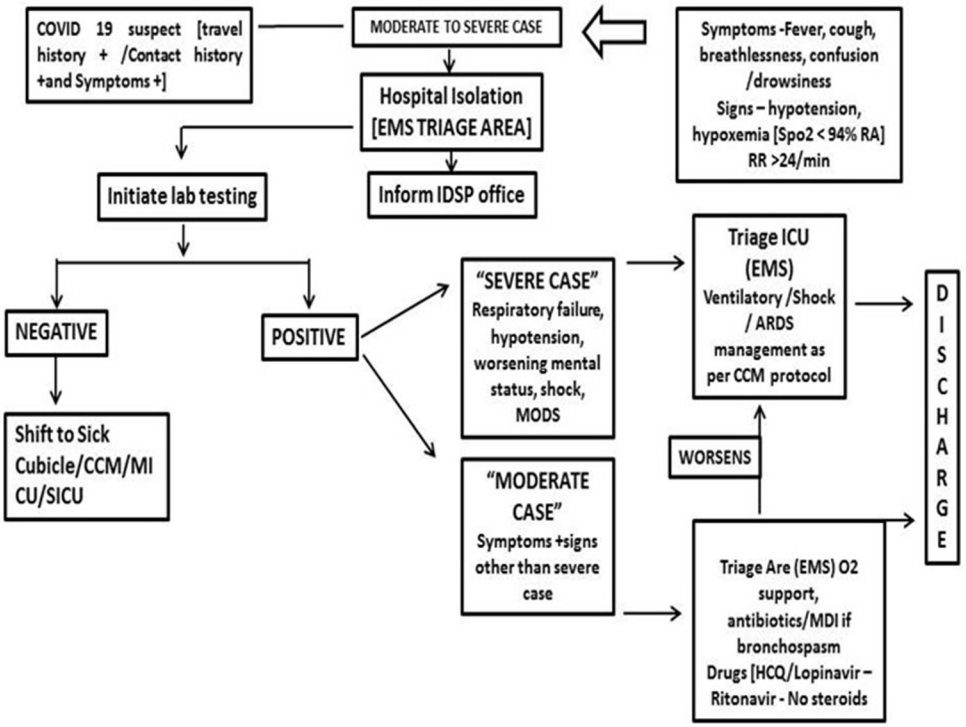

FIGURE 6 | Patient management for COVID suspects (moderate to severe case) with presenting symptoms (IDSP, integrated disease surveillance project; CCM, critical care medicine; MICU, medical intensive care unit; SICI, surgical intensive care unit; EMS, emergency medical services).

5. Logistics and Management of Supplies, Including Pharmacy Supplies

In the initial phases, there was a shortage of supplies either due to non-availability with the vendors or because transport was banned and borders were sealed. Personal protective equipment (PPE), N95 masks, and sterilant for washing hands are crucial for protecting frontline HCWs who were the worst hit. In consultation with basic virology laboratory, infectious disease experts, school of pharmacy and pharmacologists, and purchase and store managers, makeshift arrangements were made. PPE was stitched by tailors using impermeable wrapping material used for procedure trays with quality checks and supplied. N95 masks were reused using appropriate protocols particularly UV treatment of the masks with specific dosing protocols and full surface area illumination to ensure proper inactivation of viral particles with minimal mask degradation (21). Sanitizers were prepared in-house by the Department of Pharmacology using standard formulations. These alternatives with the other innate measures for non-crucial procedures aided to cope up with temporary shortages in the hospital. After the lift of the ban on travel and transport across borders, the issue pertaining to the availability of essential supplies was resolved. The purchase department in MGMCRI has ensured an uninterrupted supply of demanded items, following all the quality checks. We ensured adequate PPE (i.e., medical/surgical masks, N95/FFP2 respirators, gloves, gowns, and eye protection), which were made easily accessible to staff.

6. Essential Support Services

During the lockdown of 3 months, the services related to food and beverages (F&B), transport, laundry, medical gases, and information technology were severely jeopardized. F&B services, in general, have been outsourced for supplies in the hospital as well as for the staff, students, and visitors; transport and supply of vegetables, breads, eggs, etc. were severely affected. However, the experienced hospital personnel manager with his team effectively managed issues related to essential support services. This was possible because of linkages with local police and trustworthy vendors and transporters. The doctors on duty were provided with food prepared in the hospital kitchen on a regular basis.

The hospital has an automated laundry wing for an estimated capacity. The frequent need for a change of linen and other materials overloaded the laundry wing. Since the capacity was fixed, it was made to run overtime to manage the surge of work.

Many employees and faculty employed in the hospital travel every day from neighborhood districts outside the union territory with lockdown orders, so it was not easy for them to commute on a regular basis. Appropriate permissions were obtained and identification stickers for personal vehicles were arranged. Misuse of such permissions was also monitored. A considerable number use the hospital bus services. The challenge for the transport department of the hospital was to provide uninterrupted service with only 50% capacity in all vehicles following thorough disinfection protocols. Although the infection incidence has come down in recent times, this

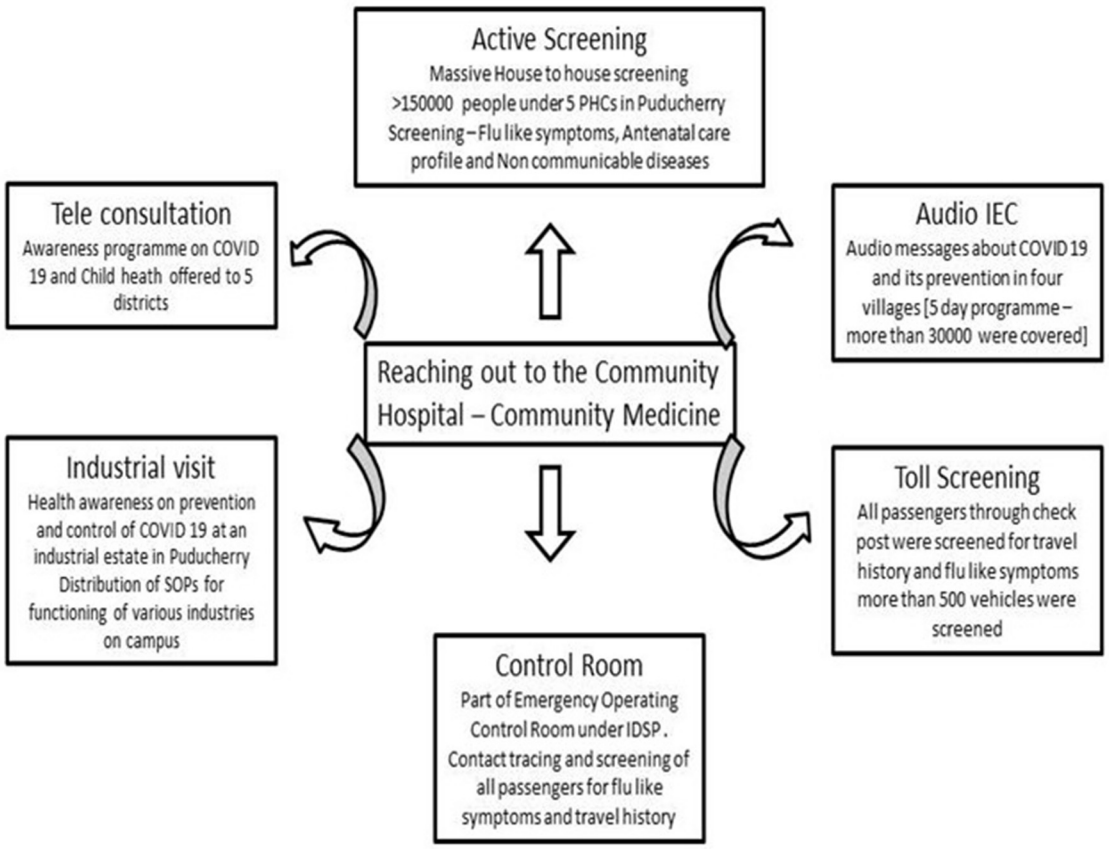

FIGURE 7 | Depiction of community services to Puducherry and neighboring places.

practice is continued with a sizable financial burden on the transport budget.

The information technology (IT) department in the hospital took no time to gear up with increased demands due to the pandemic. Since the patients are in isolation wards, the devices were installed in the wards for communication between the admitted patients and their attendants and visitors. For making payments to various hospital services, the Credit option was enabled for patients facilitating delayed payments. The IT-enabled Tele-clinic and mind clinic services support includes troubleshooting.

7. **Infection Prevention and Control**

The hospital is well-experienced in infection control. The Hospital Infection Control Committee (HICC) headed by a microbiologist plays an important role in infection prevention, surveillance, and training. The HICC besides specialized infection prevention, surveillance, training activities, rational use of PPE—a precious commodity and special needs of the biomedical waste management in laboratory and ward area was managed. The intervention was targeted to minimize the risk of transmission of health care-associated infection to patients, hospital staff, and visitors.

All entry points in the hospital, college, library, and residential areas have screening points. It was ensured that HCWs, patients, and visitors are aware of respiratory and hand hygiene and prevention of health care-associated infections and physical distancing to avoid contact and droplet transmission.

Verbal instructions are provided regularly apart from informational posters and cards, which were displayed in strategic areas. It was strictly monitored that all HCWs are applying standard precautions for all patients. Precautions on potential infection due to aerosol droplets during coughing and sneezing and physical contact are recommended for suspected or confirmed COVID-19 patients. These precautions were instructed to be continued until the patient is asymptomatic. It was ensured that all instruments used are either single use/disposable. Equipment (e.g., stethoscopes, blood pressure cuffs, thermometers, and food trays) that need to be shared among patients were instructed to be cleaned and disinfected between use for each patient with surface disinfectants. Implemented methods of routine cleaning and disinfection of ambulances follow the recommended standards and guidelines for COVID-19. A cleaning protocol for the Institute buses that ferry employees daily was also implemented.

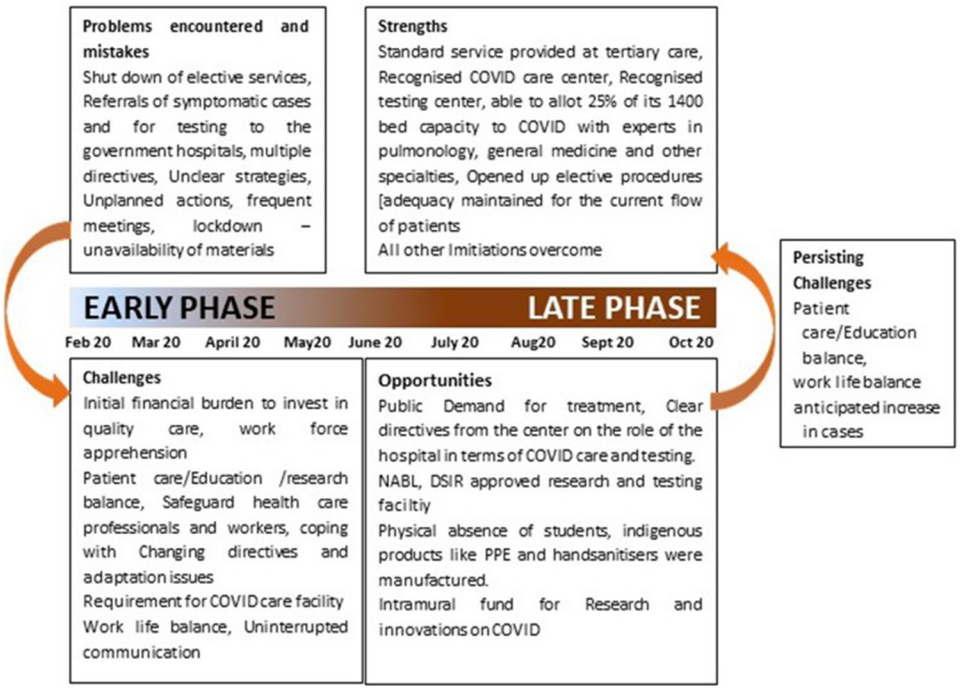

FIGURE 8 | Depiction of various problems faced, opportunities seized which was used to convert the challenges faced to strengths.

The training was given to staff on standard, contact, droplets, and airborne precautions (including correct use of PPE, donning and doffing, masks tested for fitting, hand hygiene, respiratory hygiene, etc.). The HCCC has circulated the reuse policy for N95 respirators, which has considerably brought down the usage and purchase of this commodity. It is worth mentioning that two of our infection control nurses who were certified Yellow belts in the Lean Six Sigma supervised the use of PPE and other infection control protocol compliance via their constant rounds and vigilance. In general, moving and transporting patients out of their room or general ward is avoided unless medically necessary. Designated portable X-ray equipment and/or other designated diagnostic equipment have been used all the time. If transport is required, predetermined transport routes are used to minimize exposure to staff, other patients, and visitors, and the patient has to use a medical mask if tolerable or respiratory hygiene is reinforced. Also, it was ensured that HCWs who are transporting patients perform hand hygiene and wear appropriate PPE.

The HICC prepared protocols for rational use of PPE based on the categorization of risk groups into high, moderate, and low risk based on the exposure to potential asymptomatic patients. For strict compliance, supervisors were assigned to do the job. An SOP for use of PPE in non-COVID areas was also prepared for cost-saving purposes. Outpatient and inpatient areas were identified along with their activities and responsibilities to classify them as per the above risk groups, and the use of PPE, N95 masks, protective glasses, and face shields was as accordingly recommended. Use of PPE for non-COVID patients—obstetrics and gynecology surgical patients, dialysis units, operation theaters, emergency services, and other supportive services including ambulance services—was also defined based on the aforementioned criteria and risk categories. PPE use is made mandatory for treating confirmed or suspected cases of COVID in all areas including testing centers. Specially designated lifts took care of COVID patient transport to special wards in designated isolated areas, in carefully planned exclusive circuits in a manner that is not frequented by others to avoid contamination. Pathways connecting staircases from known COVID to non-COVID areas were sealed. Visitors were restricted to those only who are found essential for patient support.

The hospital with its risk mitigation system and well-outlined protocols is supervised from time to time to take care of in-house infection spread among the workforce, residents, and patients. The contact tracing committee from the Community Medicine department took care of tracing the source of infection and possibilities of its spread among faculty, employees, and post-graduates. The tracing committee followed an SOP for the same, which included the personal details and retrospective details of the contacts, categorizing them as high, moderate, or low risk along with other presenting symptoms. Quarantine orders were tailor-made for the aforementioned risk groups, and compliance to the protocol was monitored for employees and students. Movement restriction orders and Quarantine release orders are given to people who are categorized in the risk groups. About, 89 HCWs turned out positive, of whom 41 were doctors, 36 were nurses, and 12 were other staff. Nevertheless, it was found through contact tracing that none of these HCWs contracted

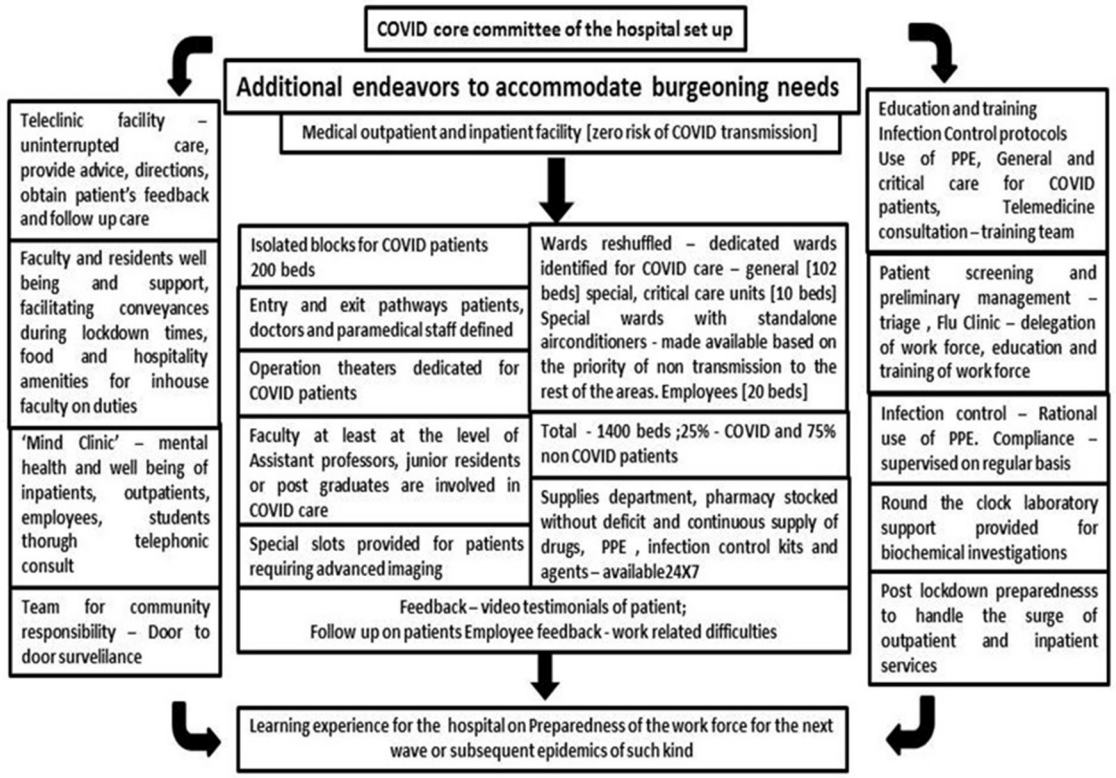

FIGURE 9 | Master work flow of coordinated response from the hospital toward COVID management.

COVID-19 in the hospital through direct patient contact while on duty, indicating SOPs for infection control implemented are effective.

8. **Patient Care**

The triage system was used to determine which groups of the patients should receive treatment and care services based on their clinical status, the prognosis of the disease, and available resources. To ensure adequate treatment of COVID-19 acute respiratory infection, an efficient and accurate triage system and an organized in-patient management strategy were implemented (**Figure 6**).

All the entry points are planned with a "*patient triage*," which monitors and categorizes patients by recording temperature and recording of symptoms and cursory examination at safe distance. SOPs were prepared for asymptomatic, mildly symptomatic, and severely symptomatic patients, and they are carefully mobilized to designated areas. As mentioned before, separate isolation wards were allotted for mild to moderate suspected cases and confirmed cases were accommodated in the dormitory. Critical care setup was augmented for confirmed and severely ill cases. Isolated labor room and operation theater (OT) procedures with negative pressure were set up by applying exhausts. One critical care facility was converted to a COVID ICU to manage COVID emergency cases. All the wards where COVID patients were kept had a standalone air-conditioner facility.

Of the 1,000 patients treated for COVID-19, 24 patients died due to cardiac arrest and two patients recovered with critical care and the remaining patients recovered eventfully over a period. The hospital with its specialists in critical care, anesthesiologists, pulmonology, and general medicine provided round-the-clock services on rotation duty with quarantine orders. Extracorporeal membrane oxygenation (ECMO) facility, which was not available in this hospital, was a limitation in providing very advanced care. As no other neighboring hospital is equipped with such a facility, patients requiring such support would be referred to another tertiary care center of the adjacent city.

We ensured that all staff were aware of the national and international guidelines (WHO and ICMR) for case management. The guidelines included case definitions for suspected/probable/confirmed cases, common clinical symptoms associated with COVID-19, indications for admissions, recommendations for testing, management of cases based on severity, discharge criteria, and recommendation on drug therapy. So far, more than 1,000 COVID patients were given the care with more than 99% to complete recovery. Common complications observed were arrhythmias and cardiac arrest. The discharge policy was also based on a

"*reverse triage*" system where priority on patient discharges was planned.

9. **Community Surveillance and Reaching out to the Society**

Recognizing and immediately reporting unusual health events (e.g., clusters of cases, atypical clinical presentations, etc.) occurring in health care facilities are the cornerstone of the early warning function. This task of early warning function by HCWs, along with the laboratory and epidemiological data obtained through systematic collection and analysis, allows the public health authorities (Director of IDSP) to monitor the progression of COVID-19 and inform interventions for those at the highest risk of the severe outcome and helps hospital managers to plan accordingly. One check post near the state border was allotted to the hospital by the state authorities to screen the national and international passengers crossing daily for symptoms of COVID-19. Information Education and Communication (IEC) materials were prepared, which were disseminated to four suburban regions of Puducherry. The hospital was allotted four primary health centers by the Ministry of Health and Family Welfare of the Government of Puducherry for a door-to-door survey program. Mobile app data collection was done for more than 80,000 people in a span of 45 days. The post-graduates of a government hospital of the neighboring state were also involved in supporting the contact tracing activities. Tele-consultation for five districts was done for patients seeking answers to COVID-related queries. These activities were undertaken by the hospital Community Medicine department jointly with the Health Department Government of Puducherry (**Figure 7**).

10. **Laboratory Services**

Laboratory services are most essential for the diagnosis and clinical management of both COVID and non-COVID patients, as well as for the hospital-based surveillance of COVID-19. The hospital has a well-equipped research laboratory (Central Interdisciplinary Research Facility), certified by the Scientific and Industrial Research Organization of the Department of Science and Industrial Research (DSIR) of the Government of India. Besides, as in every hospital, there is a Central Diagnosis Laboratory for testing parameters, such as complete blood count, biochemistry profile, electrolytes, blood gas analysis, blood culture, sputum examination, etc. However, to address COVID testing through RT-PCR, a special BSL2 laboratory accredited by NABL is mandatory to be recognized as a testing facility. Since we have had a Molecular virology lab in place with Bio Safety Laboratory (BSL-2 and BSL-3) facility in the hospital premises, we could easily manage the COVID-testing process with the available facility and expertise. In order to establish as many COVID testing laboratories as possible in the country, the Government of India desired assessors of the NABL accreditation system to fast track the process. Accordingly, the hospital premises were inspected for testing methods and SOPs through a video conference drill for 8 h starting in the evening till midnight before according accreditation certificate. NABL is an accreditation body of India and had been set up under Mutual Recognition Arrangements (MRA) signatory to International Laboratory Accreditation Cooperation (ILAC) as well as Asia Pacific Accreditation Cooperation (APAC) for the accreditation of Testing and Calibration Laboratories (ISO/IEC 17025). As of November 20, 2020, India had 1150 RT-PCR for COVID-19 in the public sector and 634 in the private sector from only 35 in March 2020.

Altogether, the hospital established a laboratory referral pathway for the sample collection, identification, confirmation, and monitoring of COVID-19. The staff has been trained on packaging and transportation procedures for specimen referrals in accordance with national and international transport regulations and requirements.

11. **The well-being of Health Care Professionals and Workers**

Well-being is the experience of health, particularly good mental health, a sense of meaning or purpose, and the ability to manage stress. Crises like these can damage the well-being of health care professionals and workers. The mission of the battle against COVID toward service and rehabilitation of society was well informed to the frontline workforce. Infrastructure and amenities for protection and health promotion were made available. The entire workforce that was on duty was provided with food and hospitality with proper hygiene precautions and infection control protocols. Many health care professions reach the hospital through public transport or private mode of conveyance crossing the borders of the union territory into the next state. Feedback from the employees was taken to address the difficulties they face in times of crisis. A team was set to analyze the feedback with necessary follow-up action. The Department of Psychiatry addressed stress and other mental health issues related to the pandemic by offering "*Mind Clinic*" —a free consultation facility with hotline numbers made accessible to faculty and students of the institute apart from its primary purpose of addressing the public.

12. **COVID Related Research Opportunities**

Alongside responding to the pandemic, COVID/general patient care, and teaching, the scope on research and innovations has also been explored. The office of the Vice president of Research, Innovation and Development has announced a "*call for innovative ideas to address unique challenges of Indian health care sectors for management of COVID-19*" for cash prizes. The Chancellor of the University encouraged potential areas of research to be identified with regard to COVID for a sumptuous grant of 20 million INR (∼280,000 USD). As we communicate this report, the hospital was given responsibility by the Central Drug Licensing Authority to conduct phase 3 clinical trials of randomized, double-blind, placebo-controlled, and multicenter study to evaluate the efficacy, safety, immunogenicity, and lot-to-lot consistency of indigenously developed whole virion inactivated SARS-COV-2 vaccine in 1,000 adults ≥18 years of age. The clinical trial is ongoing as per targets.

PROBLEMS, CHALLENGES, OPPORTUNITIES TO STRENGTH

During the pandemic and due to lockdown imposed in the country, most of the small, medium, and large hospitals had a

reduced inflow of patients and the inpatient admissions have come down from 70% to about 10–20% or maybe less in some cases. OPDs were either closed or reduced (22). So, managing hospitals in times of high risk of infection and an appalling dip in the revenue became the biggest challenge faced by hospital owners, directors, superintendents, chief executive officers, and managers (**Figure 8**).

LESSONS LEARNED

- Establishment of an HCCC is necessary with its regular meetings as the response team played a key role in the development of standard operating protocols (SOPs) tailor-made to local needs adopting and moderating the changing directives from the health authorities at national and international levels. This experience is unique and requires more documentation considering external and internal influences that permit designing SOPs that are location-specific and implementable in resource-scarce conditions (**Figure 9**).
- We learned from our experiences that integration of various resources and their coordination in terms of the cohesive workforce with an effective health care team and a response team for disaster management, flexible hospital infrastructure, state-of-the-art equipment, continuous availability of drugs and other supplies, and transport and maintenance departments are needed.
- The frontline health care professionals and workers need continuous protection to contain the infection among the workforce.
- The fear, anxiety, and apprehension among the faculty, residents, and patients need to be alleviated to promote mental health and well-being, using timely assurance and counsel by a team. Well-being can be also through care and concern, quarantine facilities, transport facilities, food, and hospitality during the duty hours.
- A trans-disciplinary team approach may be needed in such a crisis, whenever the need arises.
- Contingency in terms of financial resources, manpower (health care professionals, paramedical staff), and space availability would help to answer the needs for surge capacity. This was the toughest challenge as there was no external support. This hospital provided workforce to handle the admission and COVID patients' care in other government hospitals of this region.
- Optimizing the workforce and uninterrupted supplies of commodities for quality care were a challenge to be faced and require hospital preparedness through a response team.
- Hospitals should not only rise to the occasion for management but also assume a social responsibility of health education among the public on good practices of healthy life and good nutrition as a preventive measure in inpatient care.
- A smart leadership with good teamwork in the response team is essential to manage the workforce entrusted with COVID patient care in the frontline.
- Above all, we realized the importance of the Information and Communication Technology (ICT) platform and its utility in all forms audio-visual and telecommunication in public health care at all times and under pandemic/epidemic situations.

CONCLUSION

Hospitals are among the most complex institutions in a community. They are staffed by a multidisciplinary team delivering a multiplicity of health services to a highly diverse patient population generally suffering, collectively, from a wide range of health problems. An epidemic/pandemic requires a health facility to alter its priorities and adapt its work routines to mount a coordinated, systemic response to a rapidly evolving, potentially complex situation. Meeting the national and international guidelines and SOPs under local situations can be challenging. As detailed in the earlier pages, the experiences and the lessons learned reveal that the workforce that manages this terrible pandemic requires the right attitude, transparent communication, clear vision, togetherness, empathy, wise approach in patient care, and follow-up. The learning is never complete. Every day poses new challenges that need to be converted to opportunities to learn more and combat this global pandemic. Any mild decline in the incidence of cases and mortality rate should not create an assumption that the battle against COVID is won. A return of the wave of cases is always anticipated, which signals improved preparedness with the lessons learned over the last few months. The hospital with this experience is now equipped and trained to care for any such similar health emergency or outbreak in the future. The university with its teaching medical facility has gained definitive experience and is poised to join hands with other such health care organizations, to combat this global pandemic with its ability to successfully adapt the guidelines of state and national bodies. Despite various limitations and unexpected challenges, the strong structural reinforcement and cohesive workforce along with the transformation of the hospital being "an effective COVID care center" is a "*story of a journey worth shared*."

While Indian medical schools were set with curricula as per regulatory bodies, a sudden hairpin turn to embrace molecular diagnostics was more than challenging in terms of infrastructure and expertise at all levels. For institutions, such as MGMCRI, a hairpin turn never came because the institution had a well-established Inter-disciplinary Research & Diagnostics Center (CIDRF). Therefore, the inclusion of COVID diagnostics was only policy preparedness. On the other hand, in institutions where medical education was the only primary responsibility, the hairpin turn was a difficult makeover to manage in time. With this experience, a new theory of learning across disciplines has come into focus that has led to different approaches to the design of molecular diagnostic laboratories, highly qualified personnel to establish a functional competence, and training of the medical fraternity to relay such competence. Additionally, ICMR and NABL have rightly set regulations normalizing such establishments. Equally important, the growth of interdisciplinary approaches and new scientific collaborations

have begun to make the path from basic research to pandemic management to educational practice somewhat more visible, if not yet easy to travel.

Finally, we share our real-time ground-level experiences in the hope that the documentation will lead to more pragmatic policymaking and devising standard operating procedures in the future that are particularly tailor-made to countries with limited human, infrastructural, and financial resources and that are behind the curve in the spread of the pandemic.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

VC, SP, RP, LS, HK, AB, BSi, RK, KR, SP, and KA: Hospital Core COVID Committee. BSu and JE: lab services. PM, AP, and SR: drafting and review of manuscript. SR: initial concept, implementation, and management. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. *Epidemic Update and Risk Assessment of 2019 Novel Coronavirus—China.* (2020). Available online at: http://weekly.chinacdc.cn/en/article/doi/10.46234/ccdcw2020.024 (accessed February 8, 2021).
2. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19.* (2020). Available online at: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-$-$29-june-2020 (accessed February 8, 2021).
3. *The Public's Awareness of and Concerns About Coronavirus.* KFF (2020). Available online at: https://www.kff.org/coronavirus-covid-19/issue-brief/the-publics-awareness-of-and-concerns-about-coronavirus/ (accessed February 8, 2021).
4. Cucinotta D, Vanelli M. WHO declares COVID-19 a pandemic. *Acta Biomed.* (2020) 91:157–60. doi: 10.23750/abm.v91i1.9397
5. Chetterje P. Gaps in India's preparedness for COVID-19 control. *Lancet Infect Dis.* (2020) 20:544. doi: 10.1016/S1473-3099(20)30300-5
6. Glasziou PP, Sanders S, Hoffmann T. Waste in covid-19 research. *BMJ.* (2020) 369:m1847. doi: 10.1136/bmj.m1847
7. pdf. Available online at: https://ncdc.gov.in/WriteReadData/l892s/4241764618158452 9159.pdf (accessed February 8, 2021).
8. *Infection Prevention and Control During Health Care When Novel Coronavirus (nCoV) Infection Is Suspected*. Available online at: https://www.who.int/publications-detail-redirect/10665-331495 (accessed February 8, 2021).
9. CDC. *Healthcare Workers*. Centers for Disease Control and Prevention (2020). Available online at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/preparedness-checklists.html (accessed February 8, 2021).
10. Munn Z, Twaddle S, Service D, Harrow E, Okwen PM, Schünemann H, et al. Developing guidelines before, during, and after the COVID-19 pandemic. *Ann Intern Med.* (2020) 173:1012–14. doi: 10.7326/M20-4907
11. sgfw_ch8.pdf. Available online at: https://niti.gov.in/planningcommission.gov.in/docs/aboutus/committee/strgrp/stgp_fmlywel/sgfw_ch8.pdf (accessed February 8, 2021).
12. *Puducherry's Covid-19 Doubling Time Is 14 Days*. Puducherry News; Times of India. Available online at: https://timesofindia.indiatimes.com/city/puducherry/puducherrys-covid-19-doubling-time-is-14-days/articleshow/77656468.cms (accessed February 8, 2021).
13. Schünemann HJ, Santesso N, Vist GE, Cuello C, Lotfi T, Flottorp S, et al. Using GRADE in situations of emergencies and urgencies: certainty in evidence and recommendations matters during the COVID-19 pandemic, now more than ever and no matter what. *J Clin Epidemiol.* (2020) 127:202–7. doi: 10.1016/j.jclinepi.2020.05.030
14. Costantini M, Sleeman KE, Peruselli C, Higginson IJ. Response and role of palliative care during the COVID-19 pandemic: a national telephone survey of hospices in Italy. *Palliat Med.* (2020) 34:889–95. doi: 10.1177/0269216320920780
15. Bucci E, Andreev K, Björkman A, Calogero RA, Carafoli E, Carninci P, et al. Safety and efficacy of the Russian COVID-19 vaccine: more information needed. *Lancet.* (2020) 396:e53. doi: 10.1016/S0140-6736(20)31960-7
16. Jog S, Kelkar D, Bhat M, Patwardhan S, Godavarthy P, Dhundi U, et al. Preparedness of acute care facility and a hospital for COVID-19 pandemic: what we did! *Indian J Crit Care Med.* (2020) 24:385–92. doi: 10.5005/jp-journals-10071-23416
17. Wong J, Goh QY, Tan Z, Lie SA, Tay YC, Ng SY, et al. Preparing for a COVID-19 pandemic: a review of operating room outbreak response measures in a large tertiary hospital in Singapore. *Can J Anaesth.* (2020) 67:732–45. doi: 10.1007/s12630-020-01620-9
18. Barasa EW, Ouma PO, Okiro EA. Assessing the hospital surge capacity of the Kenyan health system in the face of the COVID-19 pandemic. *PLoS ONE.* (2020) 15:e0236308. doi: 10.1371/journal.pone.0236308
19. Yang CH, Jung H. Topological dynamics of the 2015 South Korea MERS-CoV spread-on-contact networks. *Sci Rep.* (2020) 10:4327. doi: 10.1038/s41598-020-61133-9
20. Ki HK, Han SK, Son JS, Park SO. Risk of transmission via medical employees and importance of routine infection-prevention policy in a nosocomial outbreak of Middle East respiratory syndrome (MERS): a descriptive analysis from a tertiary care hospital in South Korea. *BMC Pulm Med.* (2019) 19:190. doi: 10.1186/s12890-019-0940-5
21. Liao L, Xiao W, Zhao M, Yu X, Wang H, Wang Q, et al. Can N95 respirators be reused after disinfection? How many times? *ACS Nano.* (2020) 14:6348–56. doi: 10.1021/acsnano.0c03597
22. *Coronavirus Impact on Healthcare Sector*. The Economic Times. Available online at: https://economictimes.indiatimes.com/markets/stocks/news/coronavirus-impact-on-healthcare-sector/articleshow/75136714.cms (accessed February 8, 2021).

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OPINION
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Living and Dying With COVID-19 in South Asian Low- and Middle-Income Countries

Narayan Gyawali and Hasan Mohammad Al-Amin*

QIMR Berghofer Medical Research Institute, Brisbane, QLD, Australia

Keywords: LMICs, crisis, poverty, pandemic (COVID-19), South Asia

INTRODUCTION

The COVID-19 pandemic is a continuing disaster for global health (176 million infections and 3.8 million deaths till the date 15th June, 2021) and the world economy (losses of USD 9 trillion) but it is the poorest nations that suffer the greatest burden. In the early weeks of the pandemic, many low- and middle-income countries (LMICs) used emergency measures to adopt at least some of the non-pharmaceutical mitigation measures recommended by the WHO (1) including social distancing, local and national "lockdowns" and the closure of international borders. The consequence of these restrictions was a precipitous and insupportable loss of income for many families. Although, high-income countries (HICs) have been able to support their citizens economically during these measures, LMICs have found the trade-off between public health and the broader needs of society hard to manage. In South-Asian LMICs like Nepal, Bangladesh, and India, more than 80% of the work force operates within a poorly paid informal employment sector that spans construction, agriculture, manufacturing, trade, transport, and domestic service (2). These workers and their families rely on daily earnings and unencumbered movement to maintain a hand-to-mouth existence. They have exhausted their medical and economic resources and are now undergoing major crises (3). The plethoric consequences of the pandemic and economic crash include hunger, malnutrition (4), mental illness, and suicide (5).

The second wave of transmission is now overwhelming South-Asian LMICs (6, 7) and the sheer number of infections in India (currently >400,000/day) pose a tremendous risk to neighbors such as Nepal and Bangladesh which share long, porous borders. This article advocates for recognition of the almost insurmountable obstacles that face the implementation of non-pharmaceutical interventions for COVID-19 management in Asian LMICs and calls for a global commitment to the equitable distribution of therapeutants and vaccines.

CHALLENGES TO THE COVID-19 RESPONSE IN SOUTH-ASIAN LMICS

The recorded incidence of COVID-19 cases and deaths in many high-income countries (HICs) such as the USA and Europe recently exceeded that of Asian LMICs (7). The initial severity of the pandemic in HICs partly resulted from SARS-COV-2's rapid establishment in those countries with open borders and busy global and national transport networks. COVID related admissions to the UK's hospital reached a critical stage in many regions with a new coronavirus patient being admitted every 30 s (8). However, public health systems on the verge of collapse initially survived following robust contact tracing, wider testing and national "shelter at home" campaigns supported

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****Correspondence:***
Narayan Gyawali
narayan.gyawali@qimrberghofer.edu.au

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by overwhelming government aid. By the beginning of 2021, the immediate threat to many HICs had been mitigated by improvements in clinical management and drug treatments, and rapidly expanding vaccine programs. In contrast, some of the initial impact on LMICs may have been masked by a lack of testing capacity and the fact that most deaths in LMICs occur at home without notification of an attributable cause. In many Asian LMICs, human densities, crowded housing, the precarious nature of people's livelihoods, and the lack of government resources have challenged community compliance with "shelter at home" campaigns. With iniquitous access to public health services, ventilators, oxygen, therapeutants, and vaccines, the number of COVID-19 cases in LMICs is now greatly exceeding those recorded in HICs (7, 9). In many Asian LMICs, testing capacity remains inadequate, but in India there appear to be 4 times more daily cases now, than in their first transmission peak (September 2020). The current infection rates in neighboring Nepal and Bangladesh have also doubled their past records (7). Governments themselves have also exacerbated and facilitated transmission in some circumstances. In beginning of 2021, political leaders in Nepal organized mass rallies immediately prior to the second surge of the pandemic and, in India, the populist government endorsed attendance at religious festivals and political rallies (10). It is not known whether constantly evolving new variants are contributing to these totals but, in recent months, variants isolated in the United Kingdom (B.1.1.7), South Africa (B.1.351), and India (B.1.617) have all been implicated as causing local and regional transmission spikes (11, 12).

The WHO details nine "pillars" to support the global response to COVID-19 (1). These are intended to limit transmission, care for the affected and protect essential health services. The WHO acknowledges that these measures will cause significant stresses on society, the economy and public health and it urges mitigation of those effects through the protection of food access, livelihoods, and essential services (1). In this respect, LMICs are challenged on every front: They do not have the infrastructure necessary to provide intensive care for large numbers of patients with respiratory failure (9) and they do not have access to the diagnostics and management systems that are required for tracking COVID-19 with any precision or for overseeing the implementation of spatially targeted non-pharmaceutical interventions. LMICs already carry the greatest burden of other communicable infectious diseases such as tuberculosis, malaria, HIV/AIDS, dengue, and diarrhea (13). The immense stresses that these existing diseases place on already limited public health resources have now been eclipsed by the demands of the COVID-19 pandemic. Health outcomes and the management of all other infectious and chronic diseases are worsening.

In many Asian LMICs, the number of ICU beds is far less than required, access to drug treatments such as dexamethasone is limited, the supply of therapeutic oxygen and ventilators is inadequate (9). There are predictions of >1.5 M COVID-19 related deaths in India by August 2021 (14). The country's capacity to export vaccines abroad is in doubt, leaving neighboring countries fully exposed. In Nepal, the Ministry of Health warns that COVID-19 assigned beds are fully occupied, and the infection rate is beyond the capacity of the health system as patients queue for beds and oxygen (15) Bangladesh has a similar problem – for a population of almost 170 M people there are just 1,200 ICU beds - mostly in the private health sector (9).

THE REALITIES OF COVID-19 MANAGEMENT RESOURCES IN LMICS

As an example of the resources available to support beleaguered communities in HICs, Australia spends US$5000 on health care per capita annually and in 2020-21, expenditure on COVID-19 is expected to peak at US$ 65 billion (16) LMICs have no such resources: Bangladesh spends US$32 per capita on health care annually, that is 0.6% of the money committed for Australians, and implemented an emergency COVID-19 response programme worth 1% of GDP or US$ 3.4 billion (2), in 2020. Those sorts of funds cannot support LMICs communities through extended periods of lockdown, social distancing, and unemployment.

Non-pharmaceutical interventions have proven highly effective in COVID-19 pandemic control, in HICs. Slowdown of virus transmission due to lockdown helped them to maintain surge capacity within the healthcare system, and provided them with the opportunity to build up health care capacity and resources required for the provision of critical care, the implementation of mass testing and contact tracing, or the development and procurement of diagnostics, therapeutics and vaccines.

In contrast, the larger proportion of people from LMICs have completely different demographics and livelihoods. Many cities, such as Delhi, Dhaka, and Kathmandu are characterized by their crowded transport, living and working conditions - most earnings are unreliable and insecure and consist of carrying out manual work in exchange for low wages, yet wage earners must retain their mobility and endure close physical proximity to others, working in confined spaces regardless of the associated risks. More than 70% of urban households in Bangladesh lost the majority of their income within days of lockdown being imposed (17).

LMICs have no choice of shelter at home, working from home, online education, and online shopping. At the beginning of the pandemic, cognizant of the overwhelming challenges that lay ahead, many LMICs did act quickly to close borders and limit virus immigration. Although, lockdowns and boarder closure have slowed down the transmission of the virus at the beginning, faced with increasing transmission, little capacity for testing and contact tracing, their benefits in the long run are less clear. The simplest of mitigating measures have proved hard to implement. Even regular and effective handwashing is difficult among LMIC households that share outdoor water supplies and latrines. For many LMICs, the only pragmatic approach to the pandemic may be to focus on implementing the basic interventions of hand washing, disinfection of surfaces, the use of masks, and staying at home when symptomatic. Even those measures will require tremendous investment in community engagement, accurate

public health messaging and the provision of resources such as safe water and handwashing supplies (17).

VACCINES – ACCESSIBILITY AND INIQUITY

Twelve months after the pandemic's start there have been enormous global efforts to combat COVID-19. Multiple new vaccines, of varying efficacy, have been developed and approved for use in record time and 1.3 billion people have received at least one dose (18). However, in many LMICs without vaccine manufacturing capacity, inoculation programs have stalled and vaccine procurement through philanthropic organizations such as the Global Alliance for Vaccines (GAVI) is challenged by the individual self-interest of some HICs (19). Whilst the larger human population remains unvaccinated, COVID-19 continues to rage and the resulting international travel restrictions continue to devastate economies. Moreover, the continuing process of mutation and selection poses a risk even to those HICs with high vaccine coverage. Variants such as B.1.351 (isolated in South Africa), P.1 and P.2 (isolated in Brazil) share "escape mutations" that reduce their neutralization by the human antibodies generated by different variants or some vaccines (20). The longer that LMICs remain unvaccinated, the greater the risk to vaccine efficacy globally.

CALL FOR GLOBAL SUPPORT

Unable to afford sustained lockdowns, many communities within LMICs have had to make a choice between earning a wage and contributing reluctantly to COVID-19 transmission. Although, borders can be opened and closed with ease, most LMIC governments find national distancing measures impossible to justify or maintain because of the impact they have on the urban poor. Ultimately the world must reopen, because trade, tourism and the remittance incomes that come from emigrant employment are essential to many countries' social and economic well-being. As the pandemic and the economic crisis continue, the amount of money migrant workers send home is projected to decline by 14% by 2021, compared to the pre-COVID levels in 2019 (21).

Although, we have come to expect that the management of epidemic diseases with disproportionate burdens in LMICs is funded by coalitions of governments, banks, philanthropists, and charities, the additional funding now required for the COVID-19 response is staggering. The World Bank, in addition to its US$12 billion funding to developing countries for them to purchase and distribute COVID-19 vaccines, tests and treatment, is making available a further $160 billion to assist LMICs in mitigating the health, economic, and social shocks countries are facing (2). Organizations such as GAVI have seen billions of dollars in extra donations from its members but much more will be required if these initiatives are to have an enduring impact, not only on the health sector but also for mitigating the expected economic downturn.

In the longer term, LMICs need to develop their own capacity to manufacture and distribute vaccines. However, more than half of the population in LMICs is rural area, earning <USD 3/day, are dependent on primary health centers (2). So, production of low-cost vaccines and strengthening primary health centers is critical for them, but LMICs are challenged by their limited capacity for manufacturing test kits, limited budgets for equipment and reagents, and scant ability to make competitive bids for global supplies. Intellectual property (IP), complete or partial waiver, could be an effective way to massively scale up manufacturing of diagnostic and therapeutic needs (22). More than 100 developing nations have proposed IP amendments. HICs such as Australia, the UK, the EU did not approve those proposals.

CONCLUSIONS

Connectivity and cross-border movements have been fundamental to economic growth across the world, but they have also facilitated the pandemic. Accepting that continued mobility is required for economic sustainability, no country can thrive until all countries can manage their infection rates. As part of that effort, LMICs are now having to choose what subset of mitigating tactics they can afford. Their implementation must be weighed carefully against their feasibility and societal cost. COVID-19 now seems likely to be with us for the long term – that means that effective treatments or vaccines will be critical to solving the crisis. There should be equitable delivery without prejudice, across the globe.

AUTHOR CONTRIBUTIONS

NG and HMA conceived and wrote the manuscript. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. World Health Organisation. *COVID-19 Strategic Preparedness and Response Plan: Operational Planning Guidelines to Support Country Preparedness and Response*. Geneva: World Health Organisation (2020). Available online at: https://www.who.int/publications/m/item/covid-19-strategic-preparedness-and-response-plan-operational-planning-guideline (accessed May 25, 2021).
2. The World Bank. *Supporting Countries in Unprecedented Times. Annual Report*. (2020). Available online at: https://openknowledge.worldbank.org/handle/10986/34406 (accessed May 25, 2021).

3. Bong CL, Brasher C, Chikumba E, McDougall R, Mellin-Olsen J, Enright A. The COVID-19 pandemic: effects on low-and middle-income countries. *Anesth Analg*. (2020) 131:86–92. doi: 10.1213/ANE.0000000000004846
4. Mertens E, Peñalvo JL. The burden of malnutrition and fatal COVID-19: a global burden of disease analysis. *Front Nutr*. (2021) 7:619850. doi: 10.3389/fnut.2020.619850
5. Pokhrel S, Sedhai YR, Atreya A. An increase in suicides amidst the coronavirus disease 2019 pandemic in Nepal. *Med Sci Law*. (2020) 61:161–2. doi: 10.1177/0025802420966501
6. World Health Organisation. *COVID-19 Weekly Epidemiological Update*. (2021). Available online at: https://apps.who.int/iris/bitstream/handle/10665/340826/nCoV-weekly-sitrep13Apr21-eng.pdf?sequence=1 (accessed May 25, 2021).
7. Ritchie H, Ortiz-Ospina E, Beltekian D, Mathieu E, Hasell J, Macdonald B, et al. *Coronavirus Pandemic (COVID-19). Our World in Data.s*. (2021). Available online at: https://ourworldindata.org/coronavirus (accessed May 25, 2021).
8. Swinford S. Covid causes a hospital admission every 30 seconds, says NHS chief. *The Times*. (2021). Available online at: https://www.thetimes.co.uk/article/covid-causes-a-hospital-admission-every-30-seconds-says-nhs-chief-5d57fbpzf (accessed June 17, 2021).
9. Phua J, Faruq MO, Kulkarni AP, Redjeki IS, Detleuxay K, Mendsaikhan N, et al. Critical care bed capacity in Asian countries and regions. *Critical Care Med*. (2020) 48:654–62. doi: 10.1097/CCM.0000000000004222
10. Anon. India's COVID-19 emergency. *Lancet*. (2021) 397:1683. doi: 10.1016/S0140-6736(21)01052-7
11. Le Page M. Threats from new variants. *New Sci*. (2021) 249:8–9. doi: 10.1016/S0262-4079(21)00003-8
12. Thiagarajan K. Why is India having a covid-19 surge? *BMJ*. (2021) 30:n1124. doi: 10.1136/bmj.n1124
13. World Health Organisation. *World Health Statistics 2019: Monitoring Health for the SDGs, Sustainable Development Goals*. Geneva: World Health Organisation (2019). Available online at: https://www.who.int/publications/i/item/world-health-statistics-2019-monitoring-health-for-the-sdgs-sustainable-development-goals (accessed May 25, 2021).
14. Dhamodharavadhani S, Rathipriya R. COVID-19 mortality rate prediction for India using statistical neural networks and gaussian process regression model. *Afr Health Sci*. (2021) 21:194–206. doi: 10.4314/ahs.v21i1.26
15. Poudel A. *Nepal Health Ministry Says Situation Unmanageable as Hospitals Run Out of Beds*. The Kathmandu Post (2021). Available online at: https://kathmandupost.com/health/2021/04/30/nepal-health-ministry-says-situation-unmanageable-as-hospitals-run-out-beds (accessed May 25, 2021).
16. Australian Government. *Budget Strategy and Outlook: Budget Paper No. 1: 2020–21, Statement 6: Expenses and Net Capital Investment*. pp. 6–10. Available online at: https://budget.gov.au/2020-21/content/bp1/download/bp1_w.pdf (accessed May 25, 2021).
17. Chowdhury R, Luhar S, Khan N, Choudhury SR, Matin I, Franco OH. Long-term strategies to control COVID-19 in low and middle-income countries: an options overview of community-based, non-pharmacological interventions. *Eur J Epidemiol*. (2020) 35:743–8. doi: 10.1007/s10654-020-00660-1
18. Holder J. *Tracking Coronavirus Vaccinations Around the World*. The New York Times. Available online at: https://www.nytimes.com/interactive/2021/world/covid-vaccinations-tracker.html (accessed May 25, 2021).
19. Rouw A, Wexler A, Kates J, Michaud J. *Global COVID-19 Vaccine Access: A Snapshot of Inequality. Coronavirus (COVID-19)*. KFF Portal (2021). Available online at: https://www.kff.org/policy-watch/global-covid-19-vaccine-access-snapshot-of-inequality (accessed May 25, 2021).
20. Zhou D, Dejnirattisai W, Supasa P, Liu C, Mentzer AJ, Ginn HM, et al. Evidence of escape of SARS-CoV-2 variant B. 1.351 from natural and vaccine-induced sera. *Cell*. (2021) 184:2348–61.e6. doi: 10.1016/j.cell.2021.02.037
21. Banking Frontiers. *Remittances to LMICs to fall by 14% to $470 bn*. Available online at: https://bankingfrontiers.com/remittances-to-lmics-to-fall-by-14-to-470-bn/ (accessed May 15, 2021).
22. Sariola S. Intellectual property rights need to be subverted to ensure global vaccine access. *BMJ Global Health*. (2021) 6:e005656. doi: 10.1136/bmjgh-2021-005656

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Factors Associated With the Intention to Participate in Coronavirus Disease 2019 Frontline Prevention Activities Among Nursing Students in Vietnam: An Application of the Theory of Planned Behavior

Quynh Anh Tran[1], Huong Thi Thanh Nguyen[2], Tung Van Bui[1], Nguyet Thi Tran[3], Nguyet Thi Nguyen[3], Tham Thi Nguyen[4,5], Hien Thu Nguyen[4,5] and Son Hoang Nguyen[6]*

[1] School of Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] College of Health Sciences, VinUniversity, Hanoi, Vietnam, [3] Hanoi Medical College, Hanoi, Vietnam, [4] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [5] Faculty of Pharmacy, Duy Tan University, Da Nang, Vietnam, [6] Center of Excellence in Evidence-based Medicine, Nguyen Tat Thanh University, Ho Chi Minh, Vietnam

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***Correspondence:**
Tham Thi Nguyen
tham.ighi@gmail.com

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Introduction: Medical students have been serving as a key part of the frontline health workforce responding to the coronavirus disease 2019 (COVID-19) pandemic globally. Their contribution is especially important in the resource-scarce settings of developing nations such as Vietnam. Yet, the intention of medical students, in particular, nursing students, to participate in COVID-19 frontline prevention activities has not been well-understood. This study aimed to examine factors associated with the intentionto participate in COVID-19 frontline prevention activities among Vietnamese nursing students.

Methods: A cross-sectional study was conducted on a total of 597 students in December 2020 in Hanoi, Vietnam. Information regarding the socioeconomic characteristics of participants, their source of COVID-19 related knowledge, and their perception and attitude toward participating in COVID-19 frontline activities [based on Theory of Planned Behavior (TPB)] was collected. A hierarchical regression model was employed to examine the association between intentions of students and associated factors.

Results: A positive intention to participate in COVID-19 frontline prevention activities was found (mean score of 25.3 over 35; SD = 4.4; min = 5; max = 35). Attitude toward behavior, subjective norms, and perceived behavioral control (PBC) was found to be significantly associated with the intention of students. These variables explained the 37% variation in the intention of students in the model. Among three factors, subjective norm showed the strongest correlation with intention of students ($\beta = 0.358$; $p < 0.001$). Obtaining information from official sources and community was also found to be positively correlated with intention to participate.

Conclusion: Most of the respondents reported a positive intention to participate in COVID-19 frontline prevention activities. The findings suggested that the TPB was a good instrument to predict the intention to perform behavior among Vietnamese students. Enhancing the positive attitude of students, encouraging family and community supports, and providing adequately essential resources will contribute to optimizing the participation of students to confront COVID-19.

Keywords: intention, COVID-19, frontline, nursing students, the theory of planned behavior

INTRODUCTION

On March 11, 2020, the WHO formally declared the coronavirus disease 2019 (COVID-19) a pandemic (1), reflecting an inability to contain its spread, and as of March 28, 2021, over 126 million confirmed cases, including over 2.7 million deaths, have been reported worldwide (2). Facing the shortage of health workforce as a result of the COVID-19, expanding the health workforce by the recruitment of retirees or final year of healthcare students is a possible solution for many countries. In Denmark, final-year medical students have been employed as temporary residents at hospitals (3). In the United Kingdom, the hospitals have successfully integrated medical students into nursing teams (4). The experiences of the COVID-19 pandemic in Poland have shown that medical students who have worked voluntarily in frontline health services reported a low level of fear and received positive feedback from family, friends, patients, and healthcare workers (5). In the US, medical students can deploy to local health agencies to implement rapid testing, join student outbreak response teams, implement critical preventive policies, or be staff of community call centers that offer guidance and services to individuals with symptoms of or exposed to COVID-19 (6). Recent studies reported factors influencing the intention of medical students to work in the frontline during the COVID-19 pandemic including family support (7), the availability of protective personal equipment, and the risk of infection (8). A study in Denmark revealed that 80% of medical students in a university had decided to join the COVID-19 pandemic frontline healthcare workforce (9).

The first case of COVID-19 in Vietnam was declared on January 23, 2020, and as of March 28, 2021, over 2,500 confirmed cases and 35 deaths were reported (10). Vietnam has been acknowledged as one of the most successful countries in the world in controlling morbidity and mortality due to COVID-19 through the integration of resources from multiple sectors, such as health, mass media, education, public affairs, and defense (11). The Vietnam Ministry of Health has announced to mobilize the entire health workforce for the prevention and control of the COVID-19 pandemic, in which students at healthcare universities and colleges, including medical students, nursing students, or pharmacy students, have to be trained on disease prevention, patient care, surveillance, detection tests, and measures to prevent epidemics in the community. Furthermore, these students should be ready to voluntarily participate in COVID-19 prevention tasks when assigned (12).

According to the Theory of Planned Behavior (TPB), human behavior could be predicted by the intention to perform that behavior (13). This behavioral intention is determined by three components (**Figure 1**): attitude toward the behavior (the degree to which a person has a favorable or unfavorable evaluation of the behavior), subjective norm (perception of an individual about the particular behavior, which is influenced by the judgment of significant others such as parents or friends), and perceived behavioral control (PBC) (the perceived ease or difficulty of performing the behavior of interest) (14). The more favorable the attitude and subjective norm, and the greater the perceived control, the stronger should be the intention of the person to perform the behavior (15). This psychological theory was developed by Icek Ajzen to improve the predictive power of the Theory of Reasoned Action by adding the factor of PBC in the model (14). The TPB has been applied in many research worldwide to explain a variety of health-related behaviors, for example, taking HPV vaccination (16), using mental health services (17), or participating in physical activities (18). Furthermore, the TBP has been used to predict the behaviors of health professionals in previous studies, including the intention to care for patients with emerging infectious diseases (19) or to care for patients with severe acute respiratory syndrome (SARS) among nurses in Korea (20) and Taiwan (21). Previous studies also have demonstrated that three factors of TPB explained a 20–50% variation in the intention of the participants to perform study behavior (16, 19, 21, 22).

Although Vietnam has achieved certain success in the fight against the COVID-19 pandemic, the potential risk of new epidemic waves requires the readiness of the entire healthcare workforce, including university and college students. The nursing students are young people trained to be nurses in the future, who care directly for patients in clinical settings. This study aims to examine how TPB factors are associated with the intention to participate in COVID-19 frontline prevention activities among a sample of nursing students in Hanoi, Vietnam.

METHODS

Study Setting and Participants

A cross-sectional study was conducted on nursing students at the Hanoi Medical College in 2020. The inclusion criteria of participants in this study were as follows: (1) students in the 3-year nursing training program at Hanoi Medical College, (2) students agreeing to participate in the study through the consent

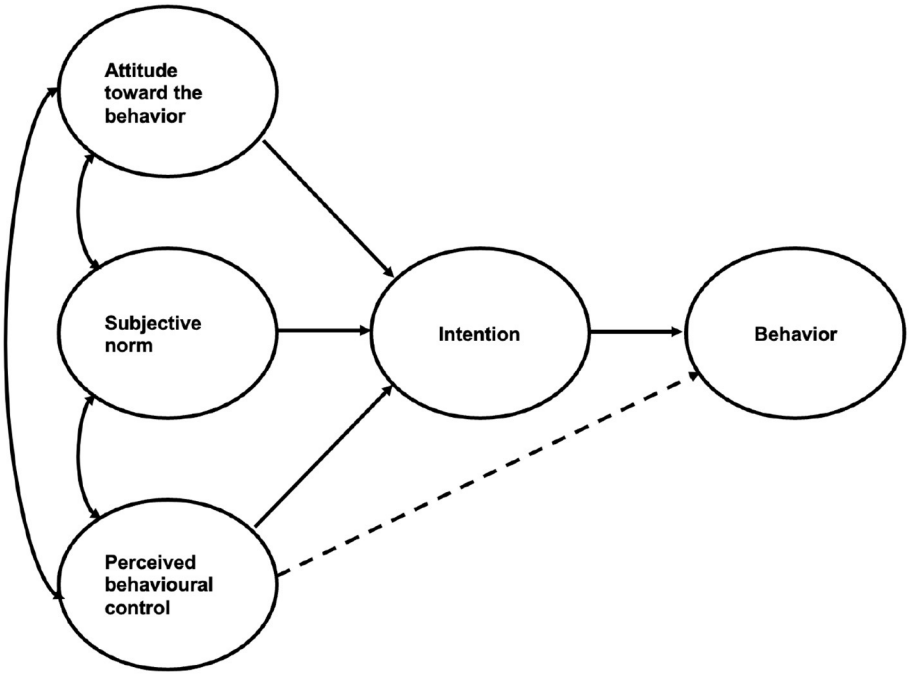

FIGURE 1 | The Theory of Planned Behavior (TPB).

form, and (3) students having the full ability to answer the question. Students who reported to be ill or unwell on the survey day were excluded. There have been about 30 classes each year with an estimated number of 25 students per class at the Hanoi Medical College. First, we randomly selected eight classes per year of education and then invited all students available in classrooms on the survey day to participate in the survey. A total of 597 students from the first year to the third year of the nursing training program completed the self-anonymous questionnaires. The response rate was 100%.

Measurement

The self-anonymous questionnaires have been developed to measure the intention of students and three associated factors based on the guideline of constructing TPB questionnaires (14, 15) and references from previous studies (19–21). The questionnaires were reviewed by three experts in the fields of nursing, behavioral sciences, and public health. Before the main survey, a pilot survey was conducted with 30 students to examine the clarity of the items, the completion of the questionnaires, and the time required. Based on the pilot study and consultation with experts, some changes were made to increase the quality of the questionnaires. All measures use a 7-point Likert scale, ranging from 1 (strongly disagree) to 7 (strongly agree). Negative items were coded reversely before scoring the scales.

The study instrument has been used to collect the following information:

Socioeconomic characteristics include age, sex, year of education, residence of the family (urban/rural), having family/relatives working in the health sector (yes/no), having elderly in the family (yes/no), living with parents/relatives (yes/no), and information sources about COVID-19.

The intention of students toward behavior was measured by a scale of five items in which respondents reported their perception of whether they would like to participate in COVID-19 frontline prevention activities in different levels such as be always ready to participate, participate when it is needed, or consider participating. Intention score of each respondent was calculated by the sum of five items. A higher score showed a more positive intention about the behavior. The intention toward behavior scale had a moderate internal consistency (Cronbach's α is 0.64). Three components predicted the intention of students:

Attitude of students toward participating in COVID-19 frontline prevention activities was measured by their belief about the benefits and disadvantages of performing the behavior (e.g., "Participating in COVID-19 frontline prevention activities is a good opportunity for learning by doing," and "Participating in COVID-19 frontline prevention activities will increase the infection risk for me"). The attitude score of each student was calculated by the sum of eight items on the scale. A higher score indicated a more positive attitude toward behavior. The attitude scale had a relatively high internal consistency (Cronbach's α is 0.76).

Subjective norm was measured by the normative beliefs of students in participating in COVID-19 frontline prevention activities by considering the support from family (parents, siblings, neighbors, and community where they are living), school (teachers, school policies), and peers (girlfriends/boyfriends, close friends, and classmates). Individual subjective norm score was calculated by the sum of seven items on the scale. A higher

score presented a greater normative belief about the behavior. The subjective norm scale had a high internal consistency (Cronbach's alpha is 0.90).

Perceived behavioral control was measured by the confidence of students in their knowledge and skill to perform the behavior. This knowledge and skill refer to the availability of institutional resources, including updated information, personal protective equipment, and assistance from other health professionals. PBC indicates the perception of students of how easy or difficult it would be to participate in COVID-19 frontline prevention activities. Individual PBC score was calculated by the sum of seven items on the scale. A higher score showed greater perceived control of the behavior. The PBC scale had a relatively high internal consistency (Cronbach's α is 0.76).

Data Analysis

Data were analyzed using STATA version 15. The intention toward behavior was treated like a dependant variable, while attitude, subjective norm, and PBC were treated as independent variables. Descriptive statistics were used to analyze the general characteristics of participants and the mean of the intention scale. The Pearson correlation was applied for scales of the TPB. The hierarchical linear regression was performed to examine the association among three TPB components and the intention of students to participate in COVID-19 frontline prevention activities controlled by general characteristics variables of the students and the sources of knowledge about COVID-19. The associations were tested using $\alpha < 0.05$ as the level of statistical significance.

The formula for a multivariable linear regression is as follows: $Y = a + b_1 * X_1 + b_2 * X_2 + \ldots + b_i * X_i$,

where Y is the dependent variable, X_i is the independent variable, a is the intercept, and b_i is the regression coefficient of the variable X_i.

We applied the hierarchical linear regression with four models:

Model 1: Students' intention = a + Attitude

Model 2: Students' intention = a + Attitude + Subjective norm

Model 3: Students' intention = a + Attitude + Subjective norm + PBC

Model 4: Students' intention = a + Attitude + Subjective norm + PBC + General characteristics of the participants + Sources of knowledge about COVID-19.

RESULTS

General Characteristics of the Participants and the Scales

Table 1 shows that, of the 597 students who completed the questionnaires, most were females (79.1%); the average age is 19.6; two-fifth of the students (39.5%) reported family relatives working in the health sector; three-fifth of the students (61.7%) reported having family residence in urban areas; half of the students (50.8%) reported living with their parents/relatives; over a half of the students (57.8%) reported having elderly in the family. Regarding the sources of knowledge about COVID-19; 58.0% of respondents reported that they receive information from the Ministry of Health, 56.0% from the community, and 23.6% from the universities.

Table 2 presents the characteristics of four scales used to measure the intention of the participants and three associated factors. Descriptive statistics show that the average score is relatively high across all assets. Among four scales, three scales measuring independent variables have high internal consistencies and normal distributions. The mean score of the intention to participate in COVID-19 frontline prevention activities was 25.3 of 35, indicating a positive attitude.

Table 3 shows statistically significant positive relationships between the intention to participate in COVID-19 frontline prevention activities and the attitude toward behavior ($r = 0.361$, $p < 0.01$), subjective norm ($r = 0.542$, $p < 0.01$), and PBC ($r = 0.491$, $p < 0.01$). Besides, bivariable correlations among three associated factors were positive and significant.

Association Between TPB Factors and the Intention of Students

Table 4 presents the relationship between three factors of TPB and the intention of students to participate in COVID-19 frontline prevention activities by hierarchical linear regression analysis. Model one showed that attitude explained a 12.9% variance in the intention of students ($\beta = 0.361$, $p < 0.001$). In model two, attitude and subjective norms explained 31.5% variance in the intention of students ($\beta = 0.167$ and 0.474, respectively; $p < 0.001$). In model three, three components of TPB explained a 35.9% variance in the intention of students. The last model explained a 37% variance in the intention of students with the entry of background variables and sources of information ($R^2 = 0.370$; $F = 23.99$, $p < 0.001$). Receiving knowledge of COVID-19 from the Ministry of health ($\beta = 0.146$, $p < 0.01$) and community ($\beta = 0.114$, $p < 0.01$) were significant variables with model changes.

DISCUSSION

To our knowledge, this is the first study to explore the intention of students to participate in the COVID-19 frontline prevention activities and associated factors based on the TPB in Vietnam. The findings revealed a positive intention to participate in COVID-19 frontline prevention activities among a sample of nursing students in Hanoi (mean score 25.3 of 35). This level of intention is higher than the intention to care for patients with SARS among nurses in Taiwan (21) and Korea (20). This difference explained by the COVID-19 mortality is relatively low in Vietnam compared to other countries in the world (10), while SARS was known as a life-threatening emerging disease with higher mortality (23), and the participation in prevention activities has a lower risk than in caring for patients. However, the mean score of the intention scale in this study is in line with the study on the intention to care for patients with emerging infectious diseases among the sample of Korean nurses (19), suggesting a similarity in risk perception among the two populations.

TABLE 1 | General characteristics of the participants and the intention score (n = 597).

	n	%	Intention (ranged score: 1–35)	
			Mean ± SD	*p*
Gender				
Male	125	20.9	25.1 ± 4.4	>0.05
Female	472	79.1	25.3 ± 4.6	
Age (mean ± SD; min; max)	19.6 ±1.5; 18; 28			
Year of education				
First-year students	198	33.2	25.8 ± 4.1	>0.05
Second-year students	202	33.8	25.4 ± 3.9	
Third-year students	197	33.0	24.7 ± 5.0	
Having family relatives work in the health sector				
Yes	236	39.5	25.5 ± 4.3	>0.05
No	361	60.5	25.1 ± 4.5	
Family's residence				
Urban area	362	61.7	25.1 ± 4.5	>0.05
Rural area	225	38.3	25.6 ± 4.3	
Living with				
Parents/relatives	303	50.8	25.6 ± 4.0	>0.05
Others	294	49.2	24.9 ± 4.8	
Elderly people in the family				
Yes	345	57.8	25.1 ± 4.5	>0.05
No	252	42.2	25.5 ± 4.3	
Sources of knowledge about COVID-19 (*A question with many answers*)				
Ministry of health	346	58.0	25.9 ± 3.7	<0.01
University/College	141	23.6	26.2 ± 3.9	<0.01
Relatives/friends	109	18.3	26.1 ± 3.9	<0.05
Community	334	56.0	25.4 ± 4.4	>0.05
Others	23	3.9	25.8 ± 4.4	>0.05

TABLE 2 | Characteristics of the scales.

Scale	Number of items	Mean; SD	Min; Max	Skewness; Kurtosis	Cronbach's α
Intention	5	25.3 ± 4.4	5–35	−1.2; 5.4	0.64
Attitude	8	38.7 ± 6.2	14–56	−0.01; 3.6	0.76
Subjective norms	7	36.2 ± 8.3	7–49	−0.7; 3.5	0.90
PBC	7	35.7 ± 5.8	11–49	−0.7; 4.2	0.76

The TPB was selected as a theoretical framework for this study because it has been used successfully to understand health-related behaviors and other professional behaviors in many countries; however, it has not been applied in Vietnam. With the aim of the study to examine the association between three components of TPB and the intention to participate in the COVID-19 frontline prevention activities, we found that attitude, subjective norm, and PBC were significant factors associated with the intention. Students who reported a more positive attitude, greater perceived support from surrounded people, and stronger PBC were more likely to have greater intention to participate in the COVID-19 frontline prevention activities when needed. The linear regression model including these three factors, controlled by the general characteristics of the respondents, has explained a 37% variance in the intention. Previous studies reported different results. A systematic review and meta-analysis on food safety behavioral intention revealed that the accumulated TPB explained 22% of the total true effect variance (22). Another study found an explanation for the 35% variance in the intention of nurses to care for patients with SARS (21) while this figure increased to 54 and 55.1% on the intention of taking HPV vaccination and the intention of nurses to care for patients with emerging infectious diseases, respectively (16, 19). Collectively, these results suggested the applicability of the TPB in predicting behavioral intention among the general population and health professionals as well.

In this study, the subjective norm was found to be the most significant among predictor variables. Subjective norm,

TABLE 3 | Correlations between the scales of the Theory of Planned Behavior (TPB).

	Intention	Attitude	Subjective norms	PBC
Intention	1			
Attitude	0.361*	1		
Subjective norms	0.542*	0.409*	1	
PBC	0.491*	0.447*	0.512*	1

$p < 0.01$; Pearson's r-values are presented.

TABLE 4 | Hierarchical linear regression of study variables.

	Model 1	Model 2	Model 3	Model 4
Attitude	0.361*	0.167*	0.093**	0.083**
Subjective norms		0.474*	0.372*	0.358*
Perceived behavioral control			0.259*	0.247*
Gender (vs. female)				
Male				−0.034
Year of education (vs. first-year students)				
Second-year student				−0.017
Third-year student				−0.034
Having family relatives work in the health sector (vs. no)				
Yes				0.015
Family's residence (vs. urban)				
Rural areas				0.005
Living with (vs. parents/relative)				
Other				0.048
Elderly people in the family (vs. no)				
Yes				0.019
Sources of knowledge about COVID-19				
Ministry of health (vs. no)				
Yes				0.146*
University (vs. no)				
Yes				0.005
Relatives/friends (vs. no)				
Yes				−0.020
Community (vs. no)				
Yes				0.114*
Others (vs. No)				
Yes				0.063
R^2	0.129	0.315	0.359	0.370
p	<0.001	<0.001	<0.001	<0.001
F	88.93	137.93	112.16	23.99

$p < 0.01$, $p < 0.05$; Standardized coefficients are presented.

a perception about behavior influenced by the judgment of significant others, was reported as the most influential factor to predict the intention to practice food safety in the US (22). In a study, Feng and Wu (24) explained the influence of Chinese and Taiwanese culture on subjective norms that then influence the behaviors of nurses in caring for patients. Taiwanese people, like many Asian people including Vietnamese, tend to be less individualistic than Western people and so their behaviors are more influenced by the values and points of view of other people (24). However, previous studies on the intention of nurses to care for patients with SARS and patients with emerging infectious diseases reported that PBC was the strongest predictor of intention (19, 21), not the subjective norm. This can be explained that nurses had experiences in their professional field then they understood better about the advantages and disadvantages of the performing behaviour than nursing students. In contrast, nursing students in our study are young people (mean age of 19.6), therefore the support of families, peers, schools, and communities is very important and strongly influenced to their normative beliefs.

The study found that obtaining COVID-19 related information from the Ministry of Health and from the community positively influences the intention of nursing students to participate in frontline prevention work. This provides some insights into the relationship between the source of information regarding COVID-19 and the desire to join the frontline medical workforce of medical students, which has otherwise been under-researched. Existing literature on the intention of medical students to participate in COVID-19 prevention activities has investigated the correlation between other factors and intention to participate. A study on Chinese medical students cited pressure and the extent of support from family as correlating factors (7), while others found sense of purpose (25, 26), desire to help (8, 25), and to learn and gain professional experience (8, 27) to be some of the most common reason for medical students to participate in frontline COVID-19 prevention activities. Knowing the possible influence of source of knowledge about COVID-19 on the intention of participation of nursing students implies that such intention can be encouraged by managing the content of information distributed through official (Ministry of Health) and community channels. It is crucial for students to receive accurate and timely information about the pandemic, particularly on issues that relate to their possible participation in prevention work, including the availability of personal protective equipment, the implementation of necessary procedures at health facilities and communities to identify and isolate possible positive case, and how participation can affect their study and possible compensation.

In the context of the COVID-19 pandemic, the mobilization of all health workforce, including medical students, nursing students, and other healthcare students, is essential to confront the shortage of human resources for both developed and developing countries. Student response teams were initially formed at the country like the US (28) and Vietnam (29) with the participation of a limited number of students and schools. In Vietnam, the capacity of local authority and community on epidemics was identified to be moderate (30). Therefore, to mobilize students effectively and broadly, understanding predictors of the behavioral intention of students will provide evidence for education and communication programs. University teachers play an important role in improving the attitudes of students to participating in COVID-19 frontline prevention activities as good opportunities for learning by doing. Communication

programs should encourage family and communities to support the activities of students. Besides, providing adequately essential resources such as protective personal equipment and updated information about the disease is needed to increase the PBC of students.

This study has some limitations. First, it is considered that other important associated factors with students might not be included in this study, for example, knowledge of students about COVID-19 prevention. This weakness should be improved in further research. Second, participants recruited from a college located in Hanoi, the capital of Vietnam, may not represent a majority of students throughout the whole country. Third, the instrument developed for the first time in Vietnamese with limited items needs to be tested further to increase the consistency and reliability of scales. Further studies are needed to overcome these limitations and examine the behavioral changes corresponding to the different stages of the epidemic.

In conclusion, this study found that most of the respondents reported a positive intention to participate in COVID-19 frontline prevention activities. Three components of TBP, namely, attitude toward behavior, subjective norm, and PBC, were significantly associated with the intention of the student, suggesting that the TPB was a good instrument to predict the intention to perform behavior among Vietnamese students. The education program should consider these factors to encourage the participation of students to confront COVID-19.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Hanoi Medical University research proposal committee, Hanoi Medical University, Hanoi, Vietnam. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

QAT, HTTN, NTT, and TTN: conceptualization. HTTN, TVB, NTT, and NTN: data curation and methodology. HTTN, TVB, NTT, TTN, and HTN: formal analysis and writing the original draft. QAT, NTN, and TTN: investigation. QAT, TTN, and SHN: supervision and writing, review, and editing. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Organization WH. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19-11 March 2020*. (2020). Available online at: https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-$-$11-march-2020 (accessed March 28, 2021).
2. World Health Organization. *WHO Coronavirus (COVID-19) Dashboard*. (2021). Available online at: https://covid19.who.int (accessed March 28, 2021).
3. Rasmussen S, Sperling P, Poulsen MS, Emmersen J, Andersen S. Medical students for health-care staff shortages during the COVID-19 pandemic. *Lancet*. (2020) 395:e79–e80. doi: 10.1016/S0140-6736(20)30923-5
4. Buckland R. Medical student volunteering during COVID-19: lessons for future interprofessional practice. *J Interprof Care*. (2020) 34:679–81. doi: 10.1080/13561820.2020.1822790
5. Bazan D, Nowicki M, Rzymski P. Medical students as the volunteer workforce during the COVID-19 pandemic: polish experience. *Int J Disaster Risk Reduc*. (2021) 55:102109. doi: 10.1016/j.ijdrr.2021.102109
6. Bauchner H, Sharfstein J. A bold response to the COVID-19 pandemic: Medical Students, National Service, and Public Health. *JAMA*. (2020) 323:1790–1. doi: 10.1001/jama.2020.6166
7. Zhan J, Sun S, Xie L, Wen Y, Fu J. Medical students' mental health, professional pride, and intention to work in the front-line during coronavirus disease 2019 pandemic. *Zhong Nan Da Xue Xue Bao Yi Xue Ban*. (2020) 45:649–56. doi: 10.11817/j.issn.1672-7347.2020.200440
8. Patel J, Robbins T, Randeva H, de Boer R, Sankar S, Brake S, et al. Rising to the challenge: Qualitative assessment of medical student perceptions responding to the COVID-19 pandemic. *Clin Med*. (2020) 20:e244–e7. doi: 10.7861/clinmed.2020-0219
9. Astorp MS, Sørensen GVB, Rasmussen S, Emmersen J, Erbs AW, Andersen S. Support for mobilising medical students to join the COVID-19 pandemic emergency healthcare workforce: a cross-sectional questionnaire survey. *BMJ Open*. (2020) 10:e039082. doi: 10.1136/bmjopen-2020-039082
10. Vietnam Ministry of Health. *News Page on the Corona virus Disease 2019 (COVID-19)*. (2021). Available online at: https://ncov.moh.gov.vn/vi/web/guest/trang-chu (accessed March 28, 2021).
11. Ha BTT, Ngoc Quang L, Mirzoev T, Tai NT, Thai PQ, Dinh PC. Combating the COVID-19 epidemic: experiences from Vietnam. *Int J Environ Res Public Health*. (2020) 17:3125. doi: 10.3390/ijerph17093125
12. Vietnam Ministry of Health. *Mobilize the Entire Healthcare Workforce for the Prevention and Control of the COVID-19 Pandemic*. (2020). Available online at: https://moh.gov.vn/tin-tong-hop/-/asset_publisher/k206Q9qkZOqn/content/huy-ong-toan-bo-luc-luong-y-te-phong-chong-ai-dich-covid-19 (accessed March 28, 2021).
13. Ajzen I. The theory of planned behavior. *Organ Behav Human Decision Process*. (1991) 50:179–211. doi: 10.1016/0749-5978(91)90020-T
14. Ajen I. *Attitudes, Personality and Behaviour, 2nd Edn*. England: Open University Press (2011).
15. Fishbein M, Ajzen I. *Predicting and Changing Behaviour: The Reasoned Action Approach*. New York, nY: Psychology Press (2010).
16. Juraskova I, O'Brien M, Mullan B, Bari R, Laidsaar-Powell R, McCaffery K. HPV vaccination and the effect of information framing on intentions and behaviour: an application of the theory of planned behaviour and moral norm. *Int J Behav Med*. (2012) 19:518–25. doi: 10.1007/s12529-011-9182-5
17. Bohon LM, Cotter KA, Kravitz RL, Cello PC, Fernandez y Garcia E. The Theory of Planned Behavior as it predicts potential intention to seek mental health services for depression among college students. *J Am College Health*. (2016) 64:593–603. doi: 10.1080/07448481.2016.1207646
18. Zhang X, Gu X, Keller J, Chen Q. Understanding physical activity behavior of Chinese female college students with/without vulnerable conditions: a theory of planned behavior perspective. *Women Health*. (2019) 59:907–20. doi: 10.1080/03630242.2019.1567647

19. Lee J, Kang SJ. Factors influencing nurses' intention to care for patients with emerging infectious diseases: Application of the theory of planned behavior. *Nurs Health Sci.* (2020) 22:82–90. doi: 10.1111/nhs.12652
20. Kim CJ, Yoo HR, Yoo MS, Kwon BE, Hwang KJ. Attitude, beliefs, and intentions to care for SARS patients among Korean clinical nurses: an application of theory of planned behavior. *Taehan Kanho Hakhoe Chi.* (2006) 36:596–603. doi: 10.4040/jkan.2006.36.4.596
21. Ko NY, Feng MC, Chiu DY, Wu MH, Feng JY, Pan SM. Applying theory of planned behavior to predict nurses' intention and volunteering to care for SARS patients in southern Taiwan. *Kaohsiung J Med Sci.* (2004) 20:389–98. doi: 10.1016/S1607-551X(09)70175-5
22. Lin N, Roberts KR. Using the theory of planned behavior to predict food safety behavioral intention: a systematic review and meta-analysis. *Int J Hosp Manag.* (2020) 90:102612. doi: 10.1016/j.ijhm.2020.102612
23. Donnelly CA, Ghani AC, Leung GM, Hedley AJ, Fraser C, Riley S, et al. Epidemiological determinants of spread of causal agent of severe acute respiratory syndrome in Hong Kong. *Lancet.* (2003) 361:1761–6. doi: 10.1016/S0140-6736(03)13410-1
24. Feng JY, Wu YW. Nurses' intention to report child abuse in Taiwan: a test of the theory of planned behavior. *Res Nurs Health.* (2005) 28:337–47. doi: 10.1002/nur.20087
25. Tempski P, Arantes-Costa FM, Kobayasi R, Siqueira MAM, Torsani MB, Amaro B, et al. Medical students' perceptions and motivations during the COVID-19 pandemic. *PLoS One.* (2021) 16:e0248627. doi: 10.1371/journal.pone.0248627
26. Lazarus G, Findyartini A, Putera AM, Gamalliel N, Nugraha D, Adli I, et al. Willingness to volunteer and readiness to practice of undergraduate medical students during the COVID-19 pandemic: a cross-sectional survey in Indonesia. *BMC Med Educ.* (2021) 21:138. doi: 10.1186/s12909-021-02576-0
27. Adejimi AA, Odugbemi BA, Odukoya OO, Okunade KS, Taiwo AO, Osibogun A. Volunteering during the COVID-19 pandemic: attitudes and perceptions of clinical medical and dental students in Lagos, Nigeria. *Niger Postgrad Med J.* (2021) 28:1–13. doi: 10.4103/npmj.npmj_379_20
28. Soled D, Goel S, Barry D, Erfani P, Joseph N, Kochis M, et al. Medical student mobilization during a crisis: lessons from a COVID-19 Medical Student Response Team. *Acad Med.* (2020) 95:1384–7. doi: 10.1097/ACM.0000000000003401
29. Tran BX, Vo LH, Phan HT, Pham HQ, Vu GT, Le HT, et al. Mobilizing medical students for COVID-19 responses: experience of Vietnam. *J Glob Health.* (2020) 10:120319. doi: 10.7189/jogh.10.0120319
30. Xuan Tran B, Thi Nguyen H, Quang Pham H, Thi Le H, Thu Vu G, Latkin CA, et al. Capacity of local authority and community on epidemic response in Vietnam: Implication for COVID-19 preparedness. *Saf Sci.* (2020) 130:104867. doi: 10.1016/j.ssci.2020.104867

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The Capacity of the Indonesian Healthcare System to Respond to COVID-19

Yodi Mahendradhata[1], Ni Luh Putu Eka Andayani[1], Eva Tirtabayu Hasri[1], Mohammad Dzulfikar Arifi[2], Renova Glorya Montesori Siahaan[2], Dewi Amila Solikha[2] and Pungkas Bahjuri Ali[2]*

[1] Center for Health Policy and Management, Faculty of Medicine, Public Health and Nursing, Universitas Gadjah Mada, Yogyakarta, Indonesia, [2] Directorate for Public Health and Nutrition, Ministry of National Development Planning, Jakarta, Indonesia

The Indonesian Government has issued various policies to fight Coronavirus Disease (COVID-19). However, cases have continued to fluctuate over a year into the pandemic. There is a need to assess the country's healthcare system's capacity to absorb and accommodate the varying healthcare demands. We reviewed the current capacity of Indonesia's healthcare system to respond to COVID-19 based on the four essential elements of surge capacity: staff, stuff, structure, and system. Currently available medical staffs are insufficient to deal with potentially increasing demands as the pandemic highlighted the human resources challenges the healthcare system has been struggling with. The pandemic has exposed the fragility of medical supply chains. Surges in the number of patients requiring hospitalization have led to depleted medical supplies. The existing healthcare infrastructure is still inadequate to deal with the rise of COVID-19 cases, which has also exposed the limited capacity of the healthcare infrastructure to manage medical waste. The COVID-19 pandemic has further exposed the weakness of the patient referral system and the limited capacity of the healthcare system to deliver essential health services under prolonged emergencies. The Indonesian Government needs to ramp up the country's healthcare capacity. A wide range of strategies has been proposed to address those mounting challenges. Notwithstanding, the challenges of increasing healthcare capacity highlight that such efforts could represent only one part of the pandemic response equation. Effective pandemic response ultimately requires governments' commitment to increase healthcare capacity and flatten the curve concurrently.

Keywords: COVID-19, pandemic, Indonesia, healthcare, surge capacity

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University of Indonesia, Indonesia

****Correspondence:***
Yodi Mahendradhata
ymahendradhata@ugm.ac.id

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INTRODUCTION

The Coronavirus Disease (COVID-19) pandemic has been an unprecedented test of healthcare systems worldwide, especially in low- and middle-income countries (1). There have been 160,813,869 confirmed cases of COVID-19 globally reported by WHO as of May 14, 2021 (2). COVID-19 has escalated demands for screening and testing suspected cases, contact tracing and isolation of cases, and managing severe cases in hospitals, including in intensive care units (ICUs)

(3). Healthcare systems generally have not been designed to meet the demands of large-scale disasters, such as pandemics (1). Even healthcare systems in high-income countries have been overwhelmed (4, 5). Therefore, a critical aspect of a country's response is the healthcare system's ability to expand quickly to meet an increased demand for medical care, commonly referred to as surge capacity (6).

Indonesia is an important bellwether for the state of democracy in the era of COVID-19 (7). It is the world's fourth most populous nation and a Muslim-majority democracy with hundreds of ethnic groups and substantial numbers of religious minorities. Alongside its size and diversity, the country shares some common features with other populous democracies like India, Brazil, and the United States (7). The first COVID-19 cases in Indonesia were confirmed on March 1, 2020 (8). The Government has since issued various policies to fight COVID-19 (9). However, over 1 year into the COVID-19 Pandemic, cases continued to fluctuate. By June 4, 2021, Indonesia had reported 1,837,126 cases and 51,095 deaths (2). The most crowded island of Java (56.1% of the country's population) has the highest caseload, with all six provinces in the island making up around 66.1% of the national tally (10). Concerns remain as to the future trajectory of COVID-19 in the country Concerns remain as to the future trajectory of COVID-19 in the country (11). Thus, there is a need to assess Indonesia's healthcare system's capacity to absorb and accommodate increasing healthcare demands. In this article, we review the current capacity of the country's healthcare system to respond to COVID-19 based on the four essential elements of surge capacity, namely, staff (e.g., healthcare workers), stuff (e.g., supplies), structure (e.g., hospital beds and medical waste treatment), and system (e.g., referral and essential health services) (12).

HEALTHCARE CAPACITY ASSESSMENT

Staff (Healthcare Workers)

Currently available medical staff in Indonesia are insufficient to deal with potentially increasing demands for managing COVID-19 cases. This pandemic highlighted the human resources challenges the country's health system has been struggling with, characterized by an inadequate physician-to-population ratio, an inequality of physician geographical distribution, and a significant shortage of nurses and midwives (13). The ratio of physicians to population stands at only 0.38 physicians per 1,000 population (14). The country's population of 264 million is currently served by only 1,206 pulmonologists, 4,134 anesthesiologists, 350 intensivists, 6,084 pediatricians and 1,811 clinical pathologists. Indonesia's COVID-19 rapid response task force has estimated that the country will need an additional 1,500 doctors (especially pulmonologists, anesthetists, and general physicians) and 2,500 nurses to manage the surge of COVID-19 patients (14). Furthermore, 22–26% of all active pulmonologists, internists, anesthesiologists, and radiologists work in DKI Jakarta, a province with 3% of the total population (15). The Ministry of Health (MoH), during the pandemic has recruited 2,785 volunteers that were assigned to two field hospitals and four other MoH-owned hospitals. The volunteers were general practitioners (62%) and nurses (27%). Only 24 (1%) of the volunteers were specialist doctors, and the rest were other healthcare professionals (16).

The shortage of healthcare professionals has been further aggravated by the deaths of healthcare professionals, which have been reported worldwide (17). High mortality and many infections have also been reported among physicians managing COVID-19 patients in Indonesia (18). As of May 3, 2021, the Indonesian Medical Association has notified 366 COVID-19 fatalities among physicians (19). Fatalities among Indonesia's frontline health workers are expected to remain high if no improvements are made. Lack of personal protective equipment (PPE) has been commonly cited as a cause of death among healthcare professionals globally (20, 21). Such lack of PPE, including coveralls, N95 masks, and face shields, has also been reported in Indonesia (18).

By May 15, 2021, the government had vaccinated 1,502,037 healthcare workers, covering practically all registered workers in the sector. Of that figure, 1,369,098 workers, or 93.15%, have received double doses of the CoronaVac, the COVID-19 vaccine made by the Beijing-based pharmaceutical company Sinovac (22). From January to March 2021, the MoH monitored 128,290 healthcare workers in Jakarta province who received the CoronaVac shot. The MoH officials reported that the vaccine was 94% effective in protecting the healthcare workers from symptomatic cases, a far higher figure than those of previous large-scale clinical trials (23).

With the escalating number of confirmed and suspected cases, the workload of healthcare workers in Indonesia has also been overwhelming, leading to long and irregular hours of continuous work, consequently triggering psychological distress (24). Indonesian healthcare workers with direct contact and responsibility to treat COVID-19 patients have reportedly exhibited a higher risk of experiencing depressive symptoms and burnout (25). It has been reported that 83% of healthcare workers in Indonesia experienced moderate to severe burnout (26). The study also found that 41% of healthcare workers were emotionally fatigued; 22% lost their sense of empathy; 52% lost their self-confidence. The most significant stressors among Indonesian healthcare workers are necessity of wearing PPE every day, hearing reports of new cases in the media, lack of staff, not knowing when COVID-19 will be brought under control, and feeling that there are no adequate protective measures (27). They also fear transmitting Covid-19 to their families. Coping mechanisms among Indonesian healthcare workers so far mainly encompass adopting a positive attitude; reading about COVID-19, how to prevent it, and how it spreads; following the appropriate steps for protection (mask, gown, etc.); avoiding public places to minimize exposure to COVID-19; and keeping busy at home to stay away from COVID-19 (27).

Stuff (Supplies)

Surges in patients requiring hospitalization have led to depleted medical supplies and escalating the utilization of limited medical equipment (e.g., ventilators). Shortage of high-flow oxygen devices and mechanical ventilation, especially in small cities and outside Java, has been reported (18). Lack of PPE for

healthcare workers such as coveralls, N95 masks, and face shields across healthcare facilities in the country is particularly worrying (18). Such shortage has been reported even in COVID-19 referral hospitals (28). In healthcare facilities where hazmat suits are severely limited, healthcare personnel must wear thin plastic raincoats when transporting patients under observation for COVID-19 (13). Some healthcare workers have had to reuse masks and gloves. This shortage was the worst when the public was panic buying and stockpiling medical-grade masks, hand sanitizers, and gloves, which caused the price to increase drastically (28). To better manage the limited supply of PPE and essential equipment, the MoH has also introduced guidelines for hospitals to differentiate distribution of PPE based on the level of risk of the hospital service area, i.e., red zone (COVID-19 areas) and green zone (Non-COVID-19 areas) (29).

The pandemic has exposed the fragility of medical supply chains in Indonesia. The medical supply system in Indonesia has so far relied mainly on the global supply chain. The People's Republic of China (PRC) produced approximately half the world's face masks (30). About 80% of active ingredients required for pharmaceutical compounding hail from China and India (31). Amid the COVID-19 outbreak in the PRC, travel bans, export bans, and factory shutdowns have put significant strain on PPE supply chains (32). To encourage business actors to support the procurement of the necessary medical equipment to halt the spread of COVID-19, the government has issued several regulations to relax licensing requirements for the importation and production of medical devices. The MoH has expedited the application process for the licenses required to produce domestically and distribute specific medical devices and household supplies to deal with COVID-19. It (i) has accelerated certification services for production and distribution certificates and (ii) offers a one-day service for marketing authorization (33). The National COVID-19 Task Force has distributed supplies across the provinces assisted by the Indonesian Armed Forces. When these supplies have reached the province, distribution to the health facilities is then managed by the provincial COVID-19 task force. By December 29, 2020, the government had already distributed 9.7 million PPE items, 25.1 million surgical masks, 7.8 million N95 masks, 1,310 portable ventilators, 1.1 million rapid tests, 5.8 million PCR reagents, and 3.8 million RNA reagents (34).

Structure (Hospital Beds and Medical Waste Treatment)

The existing healthcare infrastructure in Indonesia is inadequate to deal with the increasing demands for healthcare services. Based on data from the Health Ministry website accessed on March 7, 2021, Indonesia has 2,925 hospitals with a bed capacity of 388.106 (35). This makes the ratio of hospital beds to population 1.49 beds for every 1,000 inhabitants. Such a ratio is significantly lower than neighboring economies such as Malaysia (1.9 per 1,000 inhabitants), Thailand (2.1 per 1,000 inhabitants), and Vietnam (2.6 per 1,000 inhabitants) (13). Moreover, the hospitals and bed capacities are not evenly distributed throughout Indonesia (36). Notably, five provinces in Indonesia have not even met the ratio of 1:1,000 for the number of hospital beds compared to the population. Two hundred and twenty-six districts cannot meet this ratio, and 10 districts do not even have hospitals (36). Moreover, Indonesia, at the beginning of the pandemic only had 1,910 ICUs with 7,094 critical care beds, which translates to about 2.7 critical care beds per 100,000 population, significantly lower than neighboring countries such as Malaysia (3.4 per 100,000 population), Thailand (10.4 per 100,000 population), and Singapore (11.4 per 100,000 populations) (37). Lack of adequate facilities for treating COVID-19 cases, particularly negative pressure wards and ICU rooms, especially outside Java, has been reported (18). Many non-ICU isolation wards in Indonesian hospitals are also not in line with required standards (e.g., negative pressures, no anteroom, and no protocol).

At the beginning of the pandemic, only three hospitals in Jakarta were readily designated as referral hospitals for COVID-19 patients (18). The government since then has prepared many more additional referral hospitals (including police hospitals, military hospitals, and hospitals operated by state-owned enterprises) to manage COVID-19 patients (13). In addition to COVID-19 referral hospitals, which has been established by the MoH and the local governments, the central government at the beginning of the Pandemic has opened COVID-19 Emergency Hospital in Jakarta, which occupies a building complex that used to be athletes' residences with 10,161 beds, Indrapura Field Hospital Surabaya with 242 beds, and a special hospital on Galang Island, Batam with 360 beds. Towers 4 and 5 of athletes' residences in Kemayoran were modified into self-isolation facilities. The two towers have more than 3,000 beds. Both buildings accommodate asymptomatic patients or those with mild symptoms. Towers 6 and 7 were also modified into a COVID-19 emergency hospital, equipped with 2,878 beds for patients with mild to moderate symptoms. The emergency hospital does not have critical care facilities. Patients who experience worsening of the condition must be referred immediately to the nearest COVID-19 referral hospital. Towers 8 and 9 were modified into self-quarantine facilities with a total capacity of 4,167 beds. Meanwhile, other cities with many cases have built COVID-19 emergency hospitals utilizing government buildings, sports arenas, and hotels (38).

On March 10, 2020, 132 hospitals were designated as COVID-19 referral hospitals through the Decree of the Minister of Health No. 169/2020. The MoH subsequently issued a Circular Letter requesting the directors of hospitals owned by the MoH to convert 20–40% beds from the general ward into COVID-19 wards to increase care capacity, of which 10–25% should be allocated for critical care (39). Currently, the MoH website reports 13,854 critical care beds in ICU and 6,644 in other intensive care rooms (40). The MoH reported that the bed occupancy rate for COVID-19 patients in the second week of May 2021 was around 33%. However, the current capacity and occupancy rate still varies across provinces, and in some contexts, geographical access to these hospitals persists as a significant barrier (40).

The surge of COVID-19 cases has also exposed the limited capacity of the Indonesian healthcare infrastructure to manage medical waste. Improper disposal of medical waste has been

a major environmental problem in Indonesia even before the pandemic (41), when the estimated amount of medical waste generated from 2,813 hospitals was ±366 tons per day (42). The number has been estimated to be five times higher during the pandemic (41). Notably, only 82 hospitals (out of a total of 2,899) have licensed incinerators on their premises. The remaining hospitals have to contract private waste management companies, mostly (92%) operating on Java (43). Most of these third-party companies operated without proper procedures even before the pandemic (41). The risk of illegal dumping, cross-contamination, and disease transmission increases due to the extended distance from the hospital to the final disposal site (43). Laid-back regulation and weak monitoring have created loopholes in the medical waste management system.

The government has accordingly released a circular note 2/2020 to allow hospitals to operate unlicensed incinerators during the finalization stage of the permit attainment process in response to the concerns raised above (43). The government has also recommended that healthcare facilities should coordinate with industries to manage their medical waste disposal under the supervision of Provincial and District Health Offices. Within the next 5 years, the government will build 32 medical waste treatment facilities equipped with incinerator technology at several locations. Development in the five locations had begun in 2020, with a total capacity of 1,200 kilograms per hour, followed by development at six other locations in 2021 and seven locations for the 2022–2024 period. Notably, there has been a rise in the number of companies that offer hazardous waste treatment services, from only six companies in 2018 concentrated in Java to 20 companies, as of February 2021, with a total capacity of 384,120 kilograms of waste per day (44).

System (Referral and Essential Health Services)

The COVID-19 pandemic has exposed the weakness of the patient referral system in Indonesia. In theory, the country's referral system provides a pathway for patients to be referred from primary care facilities to secondary care facilities and subsequently to tertiary care facilities (45). However, in practice, the referral system in Indonesia, even before the pandemic, has been hampered by a shortage of specialists and poorly-equipped referral facilities, as well as weak coordination. The backbone for the referral system is SISRUTE. This internet-based service connects patient data from primary health services to higher services (horizontal and vertical), which has been implemented nationally since 2016 (46, 47). By 2020, SISRUTE has been implemented in 11,388 healthcare facilities across Indonesia, including 2,962 hospitals and 7,588 primary health care centers (47).

Unfortunately, SISRUTE implementation for COVID-19 referrals has been much less than optimal, as shown by the widespread use of other referral methods (e.g., WhatsApp messaging, phone calls); the number of hospitalized patients not in line with hospitalization criteria; and lack of real-time information (47). These deficiencies are likely to be associated with challenges for implementing SISRUTE, which include healthcare providers' commitment to real-time data entry and quick response; readiness of supporting facilities and infrastructure; and lack of supervision (47). Thus, the government urgently needs to improve SISRUTE utilization by ensuring adequate resources, training, supervision, and monitoring and evaluation. The government should also explore ways to enhance the existing referral system by adopting a digital triage system (48).

The pandemic has also revealed the limited capacity of Indonesia's healthcare system to deliver essential health services under prolonged emergencies. Health workers have reported health service disruption at the community level, with closures of nearly 76% of village health posts and suspension of over 41% of home visits (49). Health workers have also reported disruptions in various services at the primary healthcare level, including family planning, immunization, and other routine maternal and child healthcare services. Reasons for suspension of services included community safety concerns, mobility restrictions, and health workers' anxiety. Immunization services, in particular, have been disrupted in more than 90% of village health posts and 65% of primary health care centers (50). The immunization service interruption has various causes, including the high risk of local transmission of COVID-19 in the catchment areas, the limited number of dedicated vaccinators who have also been diverted to respond to COVID-19, and mobility disruptions due to travel restrictions (50).

The government had issued a recommendation to postpone routine health checks to prevent older people from being exposed to COVID-19. However, older people tend to have more chronic conditions, and fewer opportunities for health checks could undermine their health status. A recent survey showed that about 11% of older people who needed to go to health facilities during the interview found difficulty doing so (51). Nearly half of the respondents answered that they were afraid of being infected with COVID-19. About a quarter of the respondents stated that the health facilities were closed or services for older people were not available. Almost one-third of the respondents who needed consultation in health facilities postponed consultations to avoid COVID-19 exposure. About 12% of the respondents experienced a shortage of routine medicine during the pandemic. Almost half of the respondents who experienced a lack of routine drugs during the pandemic stated that they did not have money to buy medicine. The following most typical reason was the closure or absence of services for older people at health facilities or pharmacies, followed by "no one takes them to buy medicines at health facilities/pharmacies" and "no stock of medicine in health facilities" (51).

Disruption in essential health services threatens progress in the achievement of health targets. Modeling of the indirect impact of the COVID-19 pandemic on maternal and newborn health in India, Indonesia, Nigeria, and Pakistan over 12 months has projected as many as 31,980 additional maternal deaths, 395,440 additional newborn deaths, and 338,760 additional stillbirths (52). Indonesia, notably, has also experienced a significant drop by 25–30% in the reported number of people diagnosed with tuberculosis (TB) between January and June 2020 as the pandemic has reduced access to TB diagnosis and

treatment due to extra pressure on health services and impacts on care-seeking behavior (53).

DISCUSSION

Our assessment suggests that although the Indonesian Government has made considerable effort to strengthen the country's COVID-19 response, much remains to be done to improve surge capacity. While the COVID-19 pandemic is extraordinary, shortages of healthcare workers in Indonesia have been a longstanding problem. The country's physician-to-population ratio is much lower than in neighboring countries such as Vietnam (0.8 physicians per 1,000 population), Thailand (0.8 physicians per 1,000 population), and Malaysia (1.5 physicians per 1,000 population) (13). Nevertheless, shortages of healthcare workers are experienced by other countries as well. At the time of writing, India faces a severe shortage of nurses to fight the Covid-19 outbreak. India's Central Government claims it has recruited 2,206 specialist doctors, 4,685 medical officers, and 25,593 staff nurses in public hospitals across the nation under the National Health Mission since June 2020. These appointments, however, still fall short of the level the country needs (54). Workforce shortages in the UK have left the National Health Service (NHS) vulnerable to the COVID-19 outbreak. Healthcare worker shortages are a critical barrier to increasing NHS capacity and are why the Nightingale field hospitals have not been fully mobilized, despite the intense pressure on health services. The imminent risk of the NHS being overwhelmed has led to a third lockdown (55).

Thus, the Indonesian Government urgently needs to consider potentially effective human resources strategies, such as task-shifting, which have been used successfully elsewhere for chronic conditions like HIV (56). Through task-shifting, residents can be given the authority to perform tasks of pulmonologists. One ICU (Intensive Care Unit) attending could also potentially lead a team of five trained general practitioners to manage a large ICU in a COVID-19 referral hospital (57). Similar arrangements can also be considered for High Care units (HCU), Neonatal Intensive Care Units (NICU), or Pediatric Intensive Care Units (PICU) to address the limited availability of specialists. Another potential strategy is fast-tracking clinical training through an accelerated program to enable qualified personnel to enter service after a shorter intensive training period, as is implemented elsewhere for nursing (58). There have also been recommendations to consider recruiting final-year medical students to join the task force within their limits of competence (59). Meanwhile, recruiting more volunteers, especially trained nurses, and redistributing healthcare professionals within the region could optimize the allocation of existing clinical personnel. Implementation of these potential human resources strategies needs to be complemented with supervision and standing order acts to ensure effective implementation and outcomes.

Increasing mental health risks among healthcare workers handling COVID-19 patients reported in Indonesia have also been documented in other countries. A study in China reported high rates of depression (50%), anxiety (45%), insomnia (34%), and distress (72%) (60). Studies from Italy and France reported a high prevalence of depressive symptoms, post-traumatic stress disorder, and burnout (60). The long-term effect on the health of those working in healthcare remains to be seen. Thus, the Indonesian Government needs to consider potential strategies to help reduce the negative psychological responses of Indonesian healthcare workers. Resilience training (training prospectively designed to develop or enhance resilience among health professionals, e.g., the Stress Management and Resiliency Training—SMART) program has been shown to benefit healthcare workers by improving their confidence in coping with disasters (61, 62). Other strategies which have been shown to work in different settings include providing accommodation where staff could temporarily isolate themselves from their family, managing working time, and organizing psychological counselors to regularly visit rest areas to listen to difficulties or stories encountered by staff at work and provide appropriate support (63). One of the critical challenges to offer psychological support to healthcare workers is the shortage of psychologists/psychiatrists. There are only 2,500 clinical psychologists and 600–800 psychiatrists in the country, serving 260 million. The majority of them are based in Java, particularly in Jakarta (64). The triple challenges of healthcare professional shortage, physical health, and mental health could also be addressed by further harnessing telemedicine to tap into healthcare professionals in facilities not yet burdened with COVID-19 cases (13). Healthcare professionals who need to self-quarantine could also still attend to patients remotely via telemedicine. Intensive care physicians could also be deployed remotely through e-ICU solutions. Telemedicine can also be utilized for mental health education, psychological counseling services, and psychological self-help intervention systems for healthcare professionals (65).

As in virtually every country globally, Indonesia has also been seeing severe shortages of PPE and other healthcare supplies throughout the pandemic. Ensuring PPE availability for healthcare workers is critical for preventing further deaths among healthcare workers (66). Dissemination of PPE can be optimized based on risk assessments to high-contact/ transmission areas (67). This can be coupled with regular monitoring to avoid complete shortages. Additionally, there is an urgent need to improve PPE supply chains, train staff on prudent PPE use, and develop guidelines for decontamination and reuse of N95 respirators (68). The use of PPE could also be reduced for high-volume procedures with high-risk patient contact, such as throat swabbing, by adapting low-cost innovations such as swab chambers (69). The pandemic, however, has disrupted the healthcare supply chain globally. Shortages of raw materials are universal and have led to catastrophic price increases (70). Thus, the existing medical supply systems need to be enhanced to source and deliver essential commodities, including vaccines, medicines, and PPE for healthcare workers (32). The Indonesian Government needs to further increase the national production of medical supplies and equipment by encouraging domestic manufacturers of non-medical devices to reorient for the production of PPE and medical devices by further facilitating the licensing process. The government also needs to strengthen

the supply chain by managing a safer level of buffer stocks for a more extended period, coupled with introducing a real-time monitoring system to allow early warning of potential shortages. Simplification of administration and bureaucracy on logistics in times of crisis is necessary to accelerate the availability of supplies in all regions. Scaled-up implementation of telemedicine could also reduce the use of already diminishing PPE by physically separating providers from patients.

Indonesia is also not the only country struggling with the challenge of medical waste. More than 20 cities across mainland China have been overwhelmed with medical waste as of March 2020 (71). The epicenter of the COVID-19 outbreak, Wuhan, generated more than 240 tons of medical waste daily during the epidemic's peak, compared to 40 tons before COVID-19 struck. India faced the same challenge, with data shared by the Central Pollution Control Board and Uttar Pradesh, Haryana, Delhi, and Rajasthan states showing that Delhi has the highest daily rate of biomedical waste. The lockdown also disrupted sewage treatment services in the UK. Traditional waste management practices such as landfills and incinerators, which have detrimental effects on the environment, replaced more sustainable measures such as recycling. The UK Environment Agency then permitted the temporary storage of waste and burning ash on sites that had not been granted permission (71). The Indonesian Government has planned to construct a provincial-based medical waste management facility, placing incinerators in five locations, which up to 2024 will be followed gradually by additional provinces that do not have direct access to a waste management facility (43). Such a plan needs to be supplemented by accelerating the development and implementation of non-incineration medical waste treatment technology (72). The government should also consider promoting the development and broader adoption of environmentally friendly PPE (73).

Indonesia also joined many other countries reporting disruption to essential health services over 1 year into the COVID-19 pandemic (74). Millions of people globally are still missing out on vital health care. Long-term care for chronic conditions, rehabilitation, and palliative end-of-life care is still severely disrupted, seriously affecting older people and people living with disabilities (75). The government urgently needs to safeguard essential health services. Modifying essential health services by implementing triage to separate patients from the risk of COVID-19 transmission could also be considered a strategy to maintain essential health services. Implementation of telemedicine should be scaled up as it allows the delivery of health services under pandemic circumstances (13). Telemedicine has been emerging as one of the most critical tools in Indonesia's fight against COVID-19, with telemedicine firms seeing a surge of service transactions during the pandemic (13). Therefore, the government should consider collaborating with these firms to support health services provision. Digital technology could also be harnessed to support virtual monitoring and evaluation of essential health services to allow early detection of service disruptions. Several hospitals that are ready with infrastructure and systems have begun to deliver services through telemedicine.

However, the legal basis for implementing telemedicine is still lacking. The Ministry of Health has issued Regulation Number 20 of 2019 on the Implementation of Telemedicine Services between Health Services Facilities. However, this regulation only addresses the telemedicine interaction between healthcare facilities. The Pandemic has prompted MoH to issue Circular Letter No. HK.02.01/MENKES/303/2020 concerning the Organization of Health Services through the Utilization of Information and Communication Technology to Prevent the Spreading of Corona Virus 2019 Disease (COVID-19) to allow physicians to provide services through telemedicine (76). The Indonesian Medical Council (IMC) has also issued KKI Regulation No. 74 of 2020 concerning the Clinical Authority and Medical Practice through Telemedicine during the COVID-19 Pandemic. These regulations grant physicians and dentists the clinical authority to provide medical services to patients using application/electronic systems in the form of telemedicine during the COVID-19 emergency (77). Provisions of the abovementioned MoH Circular Letter and IMC regulation will only remain in effect until the Indonesian Government officially declares the end of the COVID-19 state of a public health emergency. Thus, there is still a regulatory gap to advance telemedicine implementation beyond the Pandemic. Additionally, the current state of Indonesia's telemedicine services reflects the persistent challenge of the country's inequitable digital development, with a digital infrastructure that does not cover remote areas. If the government intends to harness the full potential of telemedicine, it must be accompanied by a commitment to developing digital infrastructure so that benefits would reach remote areas (75).

The Indonesian Government needs to ramp up the country's healthcare capacity. In terms of staff, the number and distribution of healthcare workers and their well-being are still areas of concern. Concerning logistics, there is still disproportionate distribution and a lack of dependence on imports. There has been commendable progress in terms of increasing critical bed capacity. However, the capacity to process medical waste safely is generally still lacking. Disruption to essential healthcare services also requires more attention. A wide range of strategies has been proposed to address those mounting challenges, e.g., ensuring standard protection, psychological and welfare support for healthcare professionals, accelerating development, and scaling up implementation of telemedicine; promote in-country production of medical technologies and supplies. Notwithstanding, the challenges of increasing healthcare capacity highlight that such efforts could represent only one part of the pandemic response equation. Boosting healthcare capacity should be coupled with efforts to flattening the curve, e.g., suppress transmission through the implementation of effective and evidence-based public health and social measures; reduce exposure by enabling communities to adopt risk-reducing behaviors and practice infection prevention and control. Effective pandemic response ultimately requires governments' commitment to increase healthcare capacity and flatten the curve concurrently.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

YM conceptualized the idea, developed the outline, developed the first draft, managed the revisions, and finalized the manuscript. NA and EH developed the first draft and managed the revisions. MA, RS, DS, and PA critically revised the manuscript. All authors checked and approved the final version submitted.

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REFERENCES

1. Barasa EW, Ouma PO, Okiro EA. Assessing the hospital surge capacity of the Kenyan health system in the face of the COVID-19 pandemic. *PLoS ONE*. (2020) 15:e0236308. doi: 10.1371/journal.pone.0236308
2. WHO. *WHO Coronavirus Disease (COVID-19) Dashboard.* (2021). Available online at: https://covid19.who.int/ (accessed June 5, 2021).
3. WHO. *Critical preparedness, readiness and response actions for COVID-19*. WHO: Geneva (2020). Available online at: https://www.who.int/publications/i/item/critical-preparedness-readiness-and-response-actions-for-covid-19 (accessed December 31, 2020).
4. European Society of Anaesthesiology. *Analysis of COVID-19 Data on Numbers in Intensive Care From Italy*. (2020). Available online at: https://www.esahq.org/esa-news/analysis-ofcovid-19-data-on-numbers-in-intensive-care-from-italy-european-society-of-anaesthesiology-esa/ (accessed December 31, 2020).
5. IHME. COVID-19 health service utilization forecasting team, Christopher JL Murray. Forecasting COVID-19 impact on hospital bed-days, ICU-days, ventilator-days and deaths by US state in the next 4 months (2020). *medRxiv 2020.03.27.20043752*.
6. AHRQ. *Surge Capacity-Education and Training for a Qualified Workforce. Bioterrorism and Health System Preparedness Issue Brief No. 7. 2004*. (2020). Available online at: https://www.hsdl.org/?abstract&did=484701 (accessed December 31, 2020).
7. Pepinsky T. *COVID-19 and Democracy in Indonesia: Short-Term Stability and Long-Term Threats*. (2021). Available online at: https://www.brookings.edu/blog/order-from-chaos/2021/01/26/covid-19-and-democracy-in-indonesia-short-term-stability-and-long-term-threats/ (accessed May 17, 2021).
8. Setiawaty V, Kosasih H, Mardian Y, Ajis E, Prasetyowati EB, Siswanto, et al. The identification of first COVID-19 cluster in Indonesia. *Am J Trop Med Hyg*. (2020) 103:2339–42. doi: 10.4269/ajtmh.20-0554
9. Djalante R, Lassa J, Setiamarga D, Setiamarga D, Sudjatma A, Indrawan M, et al. Review and analysis of current responses to COVID-19 in Indonesia: period of January to March 2020. *Prog Disast Sci.* (2020) 6:1–9. doi: 10.1016/j.pdisas.2020.100091
10. MoH. *COVID-19 Current Condition (In Indonesian).* (2021). Available online at: https://infeksiemerging.kemkes.go.id/situasi-infeksi-emerging/situasi-terkini-perkembangan-coronavirus-disease-covid-19-12-mei-2021 (accessed May 17, 2021).
11. Gedela K, Januraga PP, Luis H, Wignall FS, Irwanto I. COVID-19 lockdown in Indonesia: greater investment will be needed to mitigate the impact on people living with HIV. *Asia Pac J Public Health.* (2020) 32:461–2. doi: 10.1177/1010539520962611
12. Barbisch DF, Koenig KL. Understanding surge capacity: essential elements. *Acad Emerg Med.* (2006) 13:1098–102. doi: 10.1111/j.1553-2712.2006.tb01630.x
13. Mahendradhata Y, Marthias T, Trisnantoro L. Indonesia. In: Legido-Quigley H, Asgari-Jirhandeh N, editors. *Resilient and People-Centred Health Systems: Progress, Challenges and Future Directions in Asia*. New Delhi: World Health Organization, Regional Office for South-East Asia (2018). p. 232–61.
14. Deloitte. *Deloitte Indonesia Business and Industry Updates: Rising to the COVID-19 Health Care Challenge in Indonesia.* (2020). Available online at: https://www2.deloitte.com/content/dam/Deloitte/id/Documents/life-sciences-health-care/id-lshc-rising-to-covid-19-health-care-challenge-in-indonesia.pdf (accessed December 31, 2020).
15. Bappenas (Agency for National Development Planning). *Comparative Study of COVID-19 Handling Indonesia-Korea (In Indonesian).* Jakarta: Ministry of National Development Planning; Agency for National Development Planning (2021).
16. MoH. *COVID-19 Meidcal Volunteers Information (In Indonesian).* (2021). Available online at: http://bppsdmk.kemkes.go.id/web/content/112/informasi-relawan-nakes-covid-19 (accessed May 17, 2021).
17. Yoshida I, Tanimoto T, Schiever N, Patelli F, Kami M. Characteristics of doctors' fatality due to COVID-19 in Western Europe and Asia-Pacific countries. *QJM.* (2020) 113:713–4. doi: 10.1093/qjmed/hcaa159
18. Yunus F, Andarini S. Letter from Indonesia. *Respirology*. (2020) 25:1328–9. doi: 10.1111/resp.13953
19. Jamaluddin M. *366 Doctors in Indonesia Have Died From Covid-19.* (2021). Available online at: https://edition.cnn.com/world/live-news/coronavirus-pandemic-vaccine-updates-05-07-21/h_e37bd5d463a8b594a9d86fc3a379e344 (accessed May 15, 2021).
20. Chersich MF, Gray G, Fairlie L, Eichbaum Q, Mayhew S, Allwood B, et al. COVID-19 in Africa: care and protection for frontline healthcare workers. *Glob Health.* (2020) 16:46. doi: 10.1186/s12992-020-00574-3
21. Ing EB, Xu QA, Salimi A, Torun N. Physician deaths from corona virus (COVID-19) disease. *Occup Med*. (2020) 70:370–4. doi: 10.1093/occmed/kqaa088
22. MoH. *COVID-19 Vaccine Situation (In Indonesian).* (2021). Available online at: https://vaksin.kemkes.go.id/#/vaccines (accessed May 15, 2021).
23. Bloomberg. *China Sinovac Shot Seen Highly Effective in Real World Study*. (2021). Available online at: https://www.bloomberg.com/news/articles/2021-05-11/china-s-sinovac-shot-found-highly-effective-in-real-world-study (accessed May 17, 2021).
24. Margaretha S, Effendy C, Kusnanto H, Hasinuddin M. Determinants psychological distress of Indonesian health care providers during COVID-19 pandemic. *Sys Rev Pharm.* (2020) 11:1052–9. doi: 10.31838/srp.2020.6.150
25. Sunjaya DK, Herawati DMD, Siregar AY. Depressive, anxiety, and burnout symptoms on health care personnel at a month after COVID-19 outbreak in Indonesia: a documentary research using Rasch model analysis. *BMC Public Health*. (2021) 21:227. doi: 10.1186/s12889-021-10299-6
26. FK UI. *Indonesian Healthcare Workers Experience Burn Out Syndrome (In Indonesian).* (2021). Available online at: https://fk.ui.ac.id/berita/83-tenaga-kesehatan-indonesia-mengalami-burnout-syndrome-derajat-sedang-dan-berat-selama-masa-pandemi-covid-19.html (accessed May 17, 2021).
27. Windarwati HD, Ati NAL, Paraswati MD, Ilmy SQ. Stressor, coping mechanism, and motivation among health care workers in dealing with stress

due to the COVID-19 pandemic in Indonesia. *Asian J Psychiatry*. (2020) 2020:102470. doi: 10.1016/j.ajp.2020.102470
28. Lauren C, Iskandar A, Argie D, Malelak EB, Suranta SE, Mawardy R, et al. Strategy within limitations during COVID-19 pandemic in Indonesia: shortage of PPE, prevention, and neurosurgery practice. *Bali Med J*. (2020) 9:682–4. doi: 10.15562/bmj.v9i3.1825
29. MoH. *Hospital Service Technical Guideline in the Era of Adapting New Normalcy (In Indonesian)*. (2021). Available online at: https://covid19.go.id/storage/app/media/Protokol/2020/November/panduan-teknis-pelayanan-rumah-sakit-pada-masa-adaptasi-kebiasaan-baru-02-11-2020.pdf (accessed May 17, 2021).
30. Ranney ML, Griffeth V, Jha AK. Critical supply shortages - the need for ventilators and personal protective equipment during the Covid-19 pandemic. *N Engl J Med*. (2020) 382:e41. doi: 10.1056/NEJMp2006141
31. Burry LD, Barletta JF, Williamson D, Kanji S, Maves RC, Dichter J, et al. It takes a village: contending with drug shortages during disasters. *Chest*. (2020) 158:2414–24. doi: 10.1016/j.chest.2020.08.015
32. Park CY, Kim K, Roth S, Beck S, Kang JW, Tayag MC, et al. *ADB BRIEFS: Global Shortage of Personal Protective Equipment Amid COVID-19: Supply Chains, Bottlenecks, and Policy Implications*. (2020). Available online at: https://www.adb.org/sites/default/files/publication/579121/ppe-covid-19-supply-chains-bottlenecks-policy.pdf (accessed December 31, 2020).
33. Raharja A. *Indonesian Government Relaxes Licensing Requirements for Medical Devices to Combat COVID-19*. (2021). Available online at: https://www.ssek.com/blog/indonesian-government-relaxes-licensing-requirements-for-medical-devices-to-combat-covid-19 (accessed May 17, 2021).
34. MoH. *Government Distribute PPE to All Regions to Control Pandemic (In Indonesian)*. (2021). Available online at: https://infobanknews.com/topnews/tangani-pandemi-pemerintah-distribusi-almatkes-ke-seluruh-wilayah/ (accessed May 17, 2021).
35. MoH. *Hospital online (In Indonesian)*. (2021). Available online at: http://sirs.yankes.kemkes.go.id/fo/ (accessed March 7, 2021).
36. Wibowo B. Meet the access and quality of hospital services (In Indonesian). In: *Forum Nila Moeloek Zoom Meeting*. Jakarta (2021).
37. Phua J, Faruq MO, Kulkarni AP, Redjeki IS, Detleuxay K, Mendsaikhan N, et al. Critical care bed capacity in Asian countries and regions. *Crit Care Med*. (2020) 48:654–62. doi: 10.1097/CCM.0000000000004222
38. Wicaksono W. *Special Content: Emergency Hospitals Emerging, Indonesian Health Services Are Struggling With COVID-19 (In Indonesian)*. (2021). Available online at: https://www.liputan6.com/news/read/4441881/special-content-rs-darurat-bermunculan-layanan-kesehatan-indonesia-kepayahan-hadapi-covid-19 (accessed May 14, 2021).
39. MOH. *Circular Letter Number. HK.02.01/Menkes/12/2021 Concerning of Increasing Coronavirus Disease 2019 (COVID-19) the Capacity of Care in COVID-19 Referral Hospital Owned by the Ministry of Health (In Indonesian)*. Jakarta: Ministry of Health, Republic of Indonesia (2021).
40. MoH. *MoH Increase Hospital Bed Capacity to Anticipate Surge After Eid (In Indonesian)*. (2021). Available online at: https://sehatnegeriku.kemkes.go.id/baca/berita-utama/20210510/0137748/antisipasi-lonjakan-kasus-pasca-lebaran-kemenkes-tambah-kapasitas-tempat-tidur-rs/ (accessed May 15, 2021).
41. Renaldi A. *Indonesia's Steady Stream of Medical Waste*. (2020). Available online at: https://pulitzercenter.org/reporting/indonesias-steady-stream-medical-waste (accessed December 31, 2020).
42. Sutrisno H, Meilasari F. Review: medical waste management for COVID-19. *J Kesehat Lingkungan*. 12:104–20. doi: 10.20473/jkl.v12i1si.2020.104-120
43. WHO. *Safe Waste Management During COVID-19 Response*. (2020). Available online at: https://www.who.int/indonesia/news/detail/21-07-2020-safe-waste-management-during-covid-19-response (accessed December 31, 2020).
44. Antara. *Ministry Develops Additional Medical Waste Treatment Facilities*. (2021). Available online at: https://en.antaranews.com/news/167421/ministry-develops-additional-medical-waste-treatment-facilities (accessed May 17, 2021).
45. MoH. *Ministry of Health Regulation No. 001 of 2012 Concerning Personal Health Service Referral System (In Indonesian)*. (2020). Available online at: http://bksikmikpikkfki.net/file/download/PMK%20No.%20001%20Th%202012%20ttg%20Sistem%20Rujukan%20Yankes%20Perorangan.pdf (accessed December 31, 2020).
46. Ansariadi, Isa A, Muh A, Pomeroy-Stevens A, Bachany D. *Building Healthy Cities Makassar Data Use and Access Assessment*. (2020). Available online at: https://indonesia.iom.int/sites/default/files/publication/BHC-Makassar-Data%20Use%20Assessment.pdf (accessed December 31, 2020).
47. Sari N, Pasinringi SA. *Implementation of the Integrated Referral System (SISRUTE) in Indonesia: Concept, Challenges and Progress*. (2020). Available online at: https://ehmaconference.org/wp-content/uploads/2020/11/IMPLEMENTATION-OF-THE-INTEGRATED-REFERRAL-SYSTEM-SISRUTE-IN-INDONESIA-CONCEPT-CHALLENGES-AND-PROGRESS.pdf (accessed December 31, 2020).
48. Lai L, Wittbold KA, Dadabhoy FZ, Sato R, Landman AB, Schwamm LH, et al. Digital triage: novel strategies for population health management in response to the COVID-19 pandemic. *Healthcare*. (2020) 8:100493. doi: 10.1016/j.hjdsi.2020.100493
49. UNICEF-MoH. *Report of Rapid Health Assessment. Ensuring Sustainability of Essential Health Services for Children and Mothers During the COVID-19 Pandemic in Indonesia*. (2020). Available online at: https://www.unicef.org/indonesia/reports/report-rapid-health-assessment (accessed December 31, 2020).
50. UNICEF-MoH 2020b. *Rapid Assessment: Immunization Services in Indonesia Impact of COVID-19 Pandemic on immunization services in Indonesia*. (2020). Available online at: https://www.unicef.org/indonesia/reports/rapid-assessment-immunization-services-indonesia (accessed December 31, 2020).
51. Komazawa O, Suriastini NW, Wijayanti IY, Maliki, Kharisma DD. *Older People and COVID-19 in Indonesia*. Jakarta: Planning Bureau for National Development (Bappenas) (2021).
52. Health Policy Plus. *Estimating the Potential Impact of COVID-19 on Mothers and Newborns in Low- and Middle-Income Countries*. Health Policy Plus 2020 (2020). Available online at: http://www.healthpolicyplus.com/Covid-mnh-impacts.cfm (accessed December 31, 2020).
53. WHO. *Global Tuberculosis Report 2020*. Geneva: World Health Organization (2020).
54. Quartz India. *Why India Is Facing a Severe Shortage of Nurses to Fight the Covid-19 Crisis*. (2021). Available online at: https://qz.com/india/2007000/why-india-is-facing-a-shortage-of-nurses-to-fight-covid-19/ (accessed May 17, 2021).
55. Charlesworth A. *Staff Shortages Left the NHS Vulnerable to the COVID-19 Storm*. (2021). Available online at: https://www.health.org.uk/news-and-comment/blogs/staff-shortages-left-the-nhs-vulnerable-to-the-covid-19-storm (accessed May 17, 2021).
56. Clumeck N. The challenge: streamlining HIV treatment and care while improving outcomes. *J Int AIDS Soc*. (2014) 17(4 Suppl. 3):19493. doi: 10.7448/IAS.17.4.19493
57. Tulenko K, D'Lima N. *How Surge Staffing Can Fight COVID-19*. (2021). Available online at: https://www.medicinenet.com/how_surge_staffing_can_fight_covid-19-news.htm (accessed June 5, 2021).
58. Millet CM, Stickler LM, Wang H. *Accelerated Nursing Degree Programs: Insights Into Teaching and Learning Experiences*. ETS Research Report No. RR-15-29 (2020). Available online at: https://files.eric.ed.gov/fulltext/EJ1109304.pdf (accessed December 31, 2020).
59. AlSaif HI, AlDhayan AZ, Alosaimi MM, Alanazi AZ, Alamri MN, Alshehri BA, et al. Willingness and self-perceived competence of final-year medical students to work as part of the healthcare workforce during the COVID-19 pandemic. *Int J Gen Med*. (2020) 13:653–61. doi: 10.2147/IJGM.S272316
60. Mehta S, Machado F, Kwizera A, Papazian L, Moss M, Azoulay E, et al. COVID-19: a heavy toll on healthcare workers. *Lancet Respir Med*. (2021) 9:226–8. doi: 10.1016/S2213-2600(21)00068-0
61. Cleary M, Kornhaber R, Thapa DK, West S, Visentin D. The effectiveness of interventions to improve resilience among health professionals: a systematic review. *Nurse Educ Today*. (2018) 71:247–63. doi: 10.1016/j.nedt.2018.10.002
62. Brooks SK, Dunn R, Amlôt R, Rubin GJ, Greenberg N. Social and occupational factors associated with psychological well-being among occupational groups affected by disaster: a systematic review. *J Ment Health*. (2017) 26:373–84. doi: 10.1080/09638237.2017.1294732
63. Chen Q, Liang M, Li Y, Guo J, Fei D, Wang L, et al. Mental health care for medical staff in China during the COVID-19 outbreak.

Lancet Psychiatry. (2020) 7:e15–6. doi: 10.1016/S2215-0366(20)30078-X
64. Pradila DA. *Why Indonesia Today Does Not Need Psychologist and Psychiatrist (In Indonesian).* (2021). Available online at: https://satupersen.net/blog/kenapa-saat-ini-indonesia-gak-butuh-psikolog-dan-psikiater (accessed May 17, 2021).
65. Preti E, Di Mattei V, Perego G, Ferrari F, Mazzetti M, Taranto P, et al. The psychological impact of epidemic and pandemic outbreaks on healthcare workers: rapid review of the evidence. *Curr Psychiatry Rep*. (2020) 22:43. doi: 10.1007/s11920-020-01166-z
66. Friese CR, Veenema TG, Johnson JS, Jayaraman S, Chang JC, Clever LH. Respiratory protection considerations for healthcare workers during the COVID-19 pandemic. *Health Secur.* (2020) 18:237–40. doi: 10.1089/hs.2020.0036
67. Nagesh S, Chakraborty S. Saving the frontline health workforce amidst the COVID-19 crisis: challenges and recommendations. *J Glob Health.* (2020) 10:010345. doi: 10.7189/jogh.10.010345
68. Le Roux C, Dramowski A. Personal protective equipment (PPE) in a pandemic: approaches to PPE preservation for South African healthcare facilities. *S Afr Med J.* (2020) 110:466–8. doi: 10.7196/SAMJ.2020.v110i6.14831
69. Tan Z, Khoo DWS, Zeng LA, Tien JCC, Lee AKY, Ong YY, et al. Protecting health care workers in the front line: Innovation in COVID-19 pandemic. *J Glob Health.* (2020) 10:010357. doi: 10.7189/jogh.10.010357
70. Khot UN. Navigating healthcare supply shortages during the COVID-19 pandemic. *Circulation.* (2020) 13:e006801. doi: 10.1161/CIRCOUTCOMES.120.006801
71. VoI. *When The Place For Processing Waste Is Inadequate, Innovation Becomes A Fixed Price.* (2021). Available online at: https://voi.id/en/tulisan-seri/32338/when-the-place-for-processing-waste-is-inadequate-innovation-becomes-a-fixed-price (accessed May 17, 2021).
72. Health Care Without Harm Europe. *Non-Incineration Medical Waste Treatment Technologies in Europe. Prague: Health Care Without Harm Europe.* (2020). Available online at: https://www.env-health.org/IMG/pdf/altech_Europe_updated_version_10_12_2004.pdf (accessed December 31, 2020).
73. Lee KP, Yip J, Kan CW, Chiou JC, Yung KF. Reusable face masks as alternative for disposable medical masks: factors that affect their wear-comfort. *Int J Environ Res Public Health.* (2020) 17:6623. doi: 10.3390/ijerph17186623
74. WHO. *Second Round of the National Pulse Survey on Continuity of Essential Health Services During the COVID-19 Pandemic*. (2021). Available online at: https://www.who.int/publications/i/item/WHO-2019-nCoV-EHS-continuity-survey-2021.1 (accessed May 17, 2021).
75. CfDS. *Telemedicine in Indonesia: A Path towards Universalizing Healthcare?*. (2021). Available online at: https://cfds.fisipol.ugm.ac.id/telemedicine-in-indonesia-a-path-towards-universalizing-healthcare/ (accessed May 17, 2021).
76. MoH. *MoH to Issue Circular Letter No. HK.02.01/MENKES/303/2020 Concerning the Organization of Health Services Through the Utilization of Information and Communication Technology to Prevent the Spreading of Corona Virus 2019 Disease (COVID-19) (In Indonesian).* (2021). Available online at: https://covid19.hukumonline.com/wp-content/uploads/2020/07/surat_edaran_menteri_kesehatan_nomor_hk_02_01_menkes_303_2020_tahun_2020.pdf (accessed June 5, 2021).
77. Indonesian Medical Council. *Indonesia. KKI Regulation No. 74 of 2020 Concerning the Clinical Authority and Medical Practice Through Telemedicine During the COVID-19 Pandemic (In Indonesian).* (2021). Available online at: http://www.kki.go.id/index.php/sideMenu/perundangan/2/72 (accessed June 5, 2021).

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Oxygen and Mortality in COVID-19 Pneumonia: A Comparative Analysis of Supplemental Oxygen Policies and Health Outcomes Across 26 Countries

Fatma Mansab[1,2], *Harry Donnelly*[3], *Albrecht Kussner*[4], *James Neil*[5], *Sohail Bhatti*[1,2] *and Daniel K. Goyal*[1,3,6]*

[1] COVID-19 Public Health Team, Public Health Gibraltar, Gibraltar, Gibraltar, [2] Postgraduate School of Medicine, University of Gibraltar, Gibraltar, Gibraltar, [3] Acute General Medicine, St Bernard's Hospital, Gibraltar Health Authority, Gibraltar, Gibraltar, [4] Emergency Medicine, St Bernard's Hospital, Gibraltar Health Authority, Gibraltar, Gibraltar, [5] Centre for Nutrition Education and Lifestyle Management (CNELM), London, United Kingdom, [6] Clinical Lecturer, Postgraduate School of Medicine, University of Gibraltar, Gibraltar, Gibraltar

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***Correspondence:**
Daniel K. Goyal
daniel.goyal@gha.gi

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Introduction: Hypoxia is the main cause of morbidity and mortality in COVID-19. During the COVID-19 pandemic, some countries have reduced access to supplemental oxygen, whereas other nations have maintained and even improved access to supplemental oxygen. We examined whether variation in the nationally determined oxygen guidelines had any association with national mortality rates in COVID-19.

Methods: Three independent investigators searched for, identified, and extracted the nationally recommended target oxygen levels for the commencement of oxygen in COVID-19 pneumonia from the 29 worst affected countries. Mortality estimates were calculated from three independent sources. We then applied both parametric (Pearson's R) and non-parametric (Kendall's Tau B) tests of bivariate association to determine the relationship between case fatality rate (CFR) and target SpO_2, and also between potential confounders and CFR.

Results: Of the 26 nations included, 15 had employed conservative oxygen strategies to manage COVID-19 pneumonia. Of them, Belgium, France, USA, Canada, China, Germany, Mexico, Spain, Sweden, and the UK guidelines advised commencing oxygen when oxygen saturations (SpO_2) fell to 91% or less. A statistically significant correlation was found between SpO_2 and CFR both parametrically ($R = -0.53$, $P < 0.01$) and non-parametrically (-0.474, $P < 0.01$).

Conclusion: Our study highlights the disparity in oxygen provision for COVID-19 patients between the nations analysed. In those nations that pursued a conservative oxygen strategy, there was an association with higher national mortality rates. We discuss the potential reasons for such an association.

Keywords: COVID-19, SARS-CoV2, oxygen, mortality, treatment, early intervention, rationing, target oxygen saturation

INTRODUCTION

SARS-CoV2 causes COVID-19 (Coronavirus Disease 2019). As of May 2020, the total reported cases of COVID-19 were over 5 million, with 350,000 deaths over 5 months (1). More than half these deaths have occurred in the last month. Whilst there has been a slight reduction in the rate of growth for new infections globally, this is most likely due to strict infection control policies (e.g., case isolation, social distancing, and "lockdown") (2). With the seroprevalence of SARS-CoV2 being reported as between <1 and 22% (3), it is most likely the majority of infections are yet to come, and the rate of infections will once again increase as infection control measures are balanced with economic pressures.

The true COVID-19 mortality rate is difficult to ascertain during the outbreak. Background infections, asymptomatic infections, testing criteria, reporting of fatalities, and the time lag between new cases and outcome are all potential confounders (4). This makes measuring the effects of national interventions difficult. It is reasonable, however, to expect that a nation's COVID-19 mortality rate will depend on access to healthcare and likely will also depend on the type of healthcare offered. The need for effective healthcare can be reasonably inferred from the marked disparity between mortality rates during a surge of cases vs. mortality post-surge (5).

Oxygen is a cornerstone of treatment for patients with COVID-19 pneumonia. Indeed, the major mechanism for injury and death in COVID-19 relates to hypoxia (6). It has been established that a delay in identifying and correcting hypoxia in pneumonia leads to increased disease severity, increased rate of mechanical ventilation, and increased mortality (7, 8). Whilst there are no controlled studies in COVID-19 specifically examining duration spent hypoxic and subsequent disease burden and mortality, Sun et al. have reported a reduction in the need for mechanical ventilation where hypoxia was detected and corrected early in patients with COVID-19 (9).

In relation to conservative oxygen strategies generally, there are four key mortality studies. The IOTA meta-analysis published in 2018 examined conservative vs. liberal oxygen strategies across a range of studies. None of the studies analysed related to pneumonia, and the majority of studies examined oxygen as a treatment not as a means to correct hypoxia. The authors suggest that optimal target oxygen saturations (SpO_2) for all acute medical patients "might" be 94–96% (10).

Since the IOTA study, there have been three clinical studies, two of which were randomised controlled trials (RCTs), examining the mortality effect of conservative oxygen strategies. The ICU-ROX trial suggests that there may be no mortality effect at the higher target levels of SpO_2 (actual mean SpO_2 96–97% vs. 95–96%) in mechanically ventilated patients from any cause ($n = 1{,}000$) (11). Another, a retrospective analysis, published in March 2020 examined over 35,000 intensive care patients and found the optimum SpO_2 target of 94–98%. The authors note that patients who were in the optimal range for only 40% of the time had nearly twice the mortality of those who spent 80% of the time within the optimal target, even after correction for disease severity (12).

The most recent RCT, and the most well-controlled study of true conservative oxygen strategies to date (and the most relevant to COVID-19), examined 204 patients with acute respiratory distress syndrome (ARDS). Patients were randomised to either a conservative arm (actual SpO_2 of 92–93%) vs. a liberal arm (SpO_2 of 95–97%) and then followed up for 90 days. The study was halted early due to excessive deaths in the conservative oxygen group. In those patients with ARDS who were managed with a conservative oxygen strategy, there was a 27% increase in intensive care deaths and a 50% increase in 90-day mortality (13).

Despite the critical nature of oxygen therapy in COVID-19 pneumonia, there remains a marked variation between national guidelines for when to offer supplemental oxygen. Many nations seem to have implemented conservative oxygen strategies during the pandemic, effectively limiting the access of patients to supplemental oxygen. Others seem to have actively increased their capacity to offer supplemental oxygen for patients with COVID-19 pneumonia. Here, we examine the national guidelines from 29 nations to ascertain whether the national decision to promote a "conservative" oxygen strategy has any relationship to that nation's case fatality rate (CFR).

METHODS

We followed the advice for global reporting on health estimates as per the GATHER statement (14). All countries with more than 20,000 cases as of May 18, 2020, were assessed. Three investigators (DG, AK, and HD) independently identified the specific national recommendations for the target SpO_2 to commence oxygen in patients with COVID-19. Two investigators (AK and HD) were blinded as to the reason for the study. Each nation's ministry of health, national guideline bodies, respiratory medicine bodies, and national health service were searched for relevant COVID-19 clinical guidelines. The European Society of Respiratory Medicine (15) was a useful resource with direct links to a number of COVID-19-specific clinical guidelines from across the world. Literature databases were also used as a means of identifying links to national guidelines. If guidelines were not available in one of the languages spoken by the investigators, online translation services were utilised, specifically for guidelines on "supplemental oxygen" or "oxygen therapy"—the entire guideline was not translated. Note, only guidelines applicable to the majority of the population were extracted, and guidelines for patients with underlying conditions such as chronic obstructive airways disease were not recorded.

If guidelines were unclear, instruction was to disregard the country from further analysis. Where there was more than one recommendation, the investigator made a determination as to the most likely guideline to be followed (**Figure 1**). Where there was divergence between the three investigators, the consensus value was used. Results were tabulated and compared.

CFR and Infection Fatality Rate

CFR is the percentage ratio of deaths to total cases. It is a crude figure privy to a number of potential confounders. For most nations, it is likely to be numerically incorrect (4). CFR, however, is likely to maintain a relationship to actual infection mortality

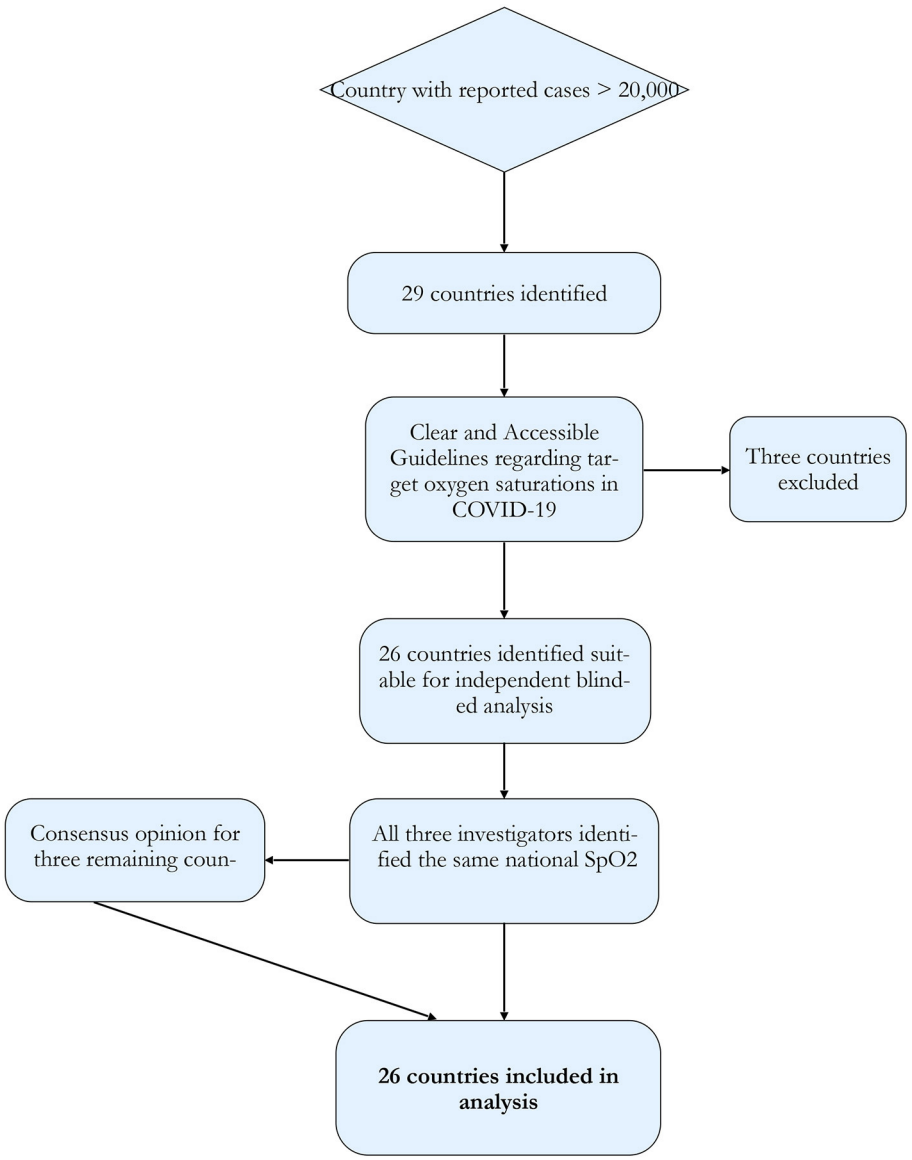

FIGURE 1 | Study protocol flowchart. Using the WHO situation report countries with case numbers over 20,000 were selected. These countries were subjected to analysis *via* three different, independent investigators for the ascertainment of nationally recommended target oxygen saturations.

rate (IFR) (3, 4) and as such was used in this study. CFR was calculated and cross-referenced from three different sources—The WHO, John Hopkins University, and Worldometer. There was no significant difference between the calculated CFR across the three sources.

Statistical Analysis

All statistics were performed using SPSS. Both parametric (Pearson's R) and non-parametric (Kendall's Tau B) tests of bivariate association were performed to identify and characterised a potential trend between CFR and target SpO_2, as given the small sample size it was not clear whether the assumptions of linearity, homoscedasticity, and normality of variables were met. Kendall's Tau B was used as the test of non-parametric bivariate association as there were ties in both CFR and SpO_2, which are problematic for Spearman's Rho.

Scatter plots with linear regression lines of best fit are also given, as well as the y-intercept and gradient of these lines reported. Means and standard errors of CFR, SpO_2, and confounding variables are given.

RESULTS

In total, there were 29 countries with a total case number over 20,000 on May 18, 2020. Of those, 26 countries had accessible clinical guidelines referring to target oxygen levels for

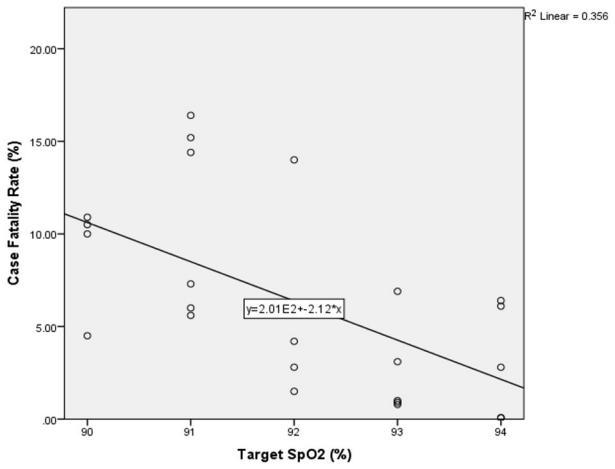

FIGURE 2 | Scatter graph of national target oxygen saturations vs. national case fatality rate with best fit linear line ($n = 26$). SpO_2–oxygen saturations.

the commencement of supplemental oxygen in COVID-19. UAE (United Arab Emirates) was excluded from further analysis as the national guidelines advised (at page 9) admitting all patients with COVID-19 to hospital, and commencing oxygen when "needed" (16). The Netherlands and Belarus were also excluded due to all three investigators failing to find clear national guidelines regarding oxygen targets.

Of the remaining 26 countries, there was concordance between all three investigators identifying the same national target oxygen levels in 23 countries. Of the remaining three countries (UK, Pakistan, and Qatar), determination of national target SpO_2 in COVID-19 was made by consensus. For links to national guidelines, see **Supplementary Material**.

Of the 26 nations analysed, six recommended commencing oxygen if SpO_2 fell to below 95% (Singapore, Peru, Switzerland, Ireland, Qatar, and Pakistan), five made recommendation for below 94% (Saudi Arabia, Chile, Brazil, India, and Russia), five for below 93% (Portugal, Iran, Turkey, Bangladesh and Italy), six for below 92% (Canada, Belgium, France, UK, USA, and China), and four for below 91% (Germany, Mexico, Spain, and Sweden). CFR ranged from 0.06% (Qatar) to 16.4% (Belgium). A statistically significant correlation was found between SpO_2 and CFR both parametrically ($R = -0.53$, $P < 0.01$) and non-parametrically (-0.474, $P < 0.01$), and no statistically significant correlation was found with the potential confounders analysed here. A scatter graph with the linear best-fit line is shown in **Figures 2**, **3A**.

Confounders

National guidelines for target saturations were relatively clear for most countries. Together with the high rate of consensus amongst investigators, it seems unlikely that investigator bias was a significant factor. The main confounders are more likely to stem from the many variables associated with CFR.

We found no correlation between CFR and cases/million inhabitants (**Figure 3B**), or tests/thousand inhabitants (**Figure 3C**), or overall positivity rate (**Figure 3D**), suggesting that the testing strategy between the countries examined did not have a significant visible relationship with our mortality measure, CFR (**Table 1**). We could not examine the potential impact of national-level reporting bias on the CFR from the data available.

DISCUSSION

National guidelines for when to commence supplemental oxygen in patients with COVID-19 varied significantly between the countries examined. Combined, the target SpO_2 for the commencement of oxygen and target SpO_2 for ongoing treatment varied from 90% to 98%. There are a number of potential reasons for the variation in oxygen policies between countries and the association with mortality.

Causative Effect

Based on the design of the study, a causal relationship between national oxygen targets and national CFR cannot be determined. However, our analysis did reveal an association between national target oxygen saturations and national CFR—the lower the national target oxygen saturations, the higher the national CFR. One possible explanation for the identified relationship is that the national guidelines have been followed and implemented, and it is the lower oxygen levels during COVID-19 pneumonia that has led to an increased mortality.

Based on our current understanding of the effects of hypoxia on inflammation (17) and coagulation (18), there is good scientific basis for the increased mortality associated with suboptimal oxygen strategies and/or a delay in correcting hypoxia. There are direct effects of hypoxia leading to increased mortality, such as cardiac arrhythmias and ischemia-related pathologies [as identified in the aforementioned ARDS study (13)]. It is also quite plausible, indeed quite likely, given that hypoxia is pro-inflammatory, the delay in correcting hypoxia leads to more severe disease. This of course raises the possibility that rationing, or a conservative oxygen approach, or a failure to provide access to supplemental oxygen in COVID-19 pneumonia, actually increases healthcare burden and resource consumption (19).

The presence of "silent hypoxia"—low oxygen levels without respiratory distress—is likely to compound the mortality effect of reduced access to supplemental oxygen. A fall below normal SpO_2 (95% or less) indicates progression of COVID-19 to pneumonia or pneumonitis. If sent home at this stage despite evidence for disease progression, around one-third of patients will be unaware of their own deterioration and therefore will either fail to re-present and demise at home, or will present even later (20). This will almost certainly add greater pressure on ICU facilities and increase morbidity and mortality. Conservative oxygen strategies are questionable at the best of times (19); with COVID-19, such strategies likely carry even greater harm. Optimal oxygen strategies have the additional benefit of identifying and observing these at-risk "silent hypoxia" patients.

Resource Limitations

An alternative explanation for the relationship between national oxygen targets and mortality is that the recommendation to

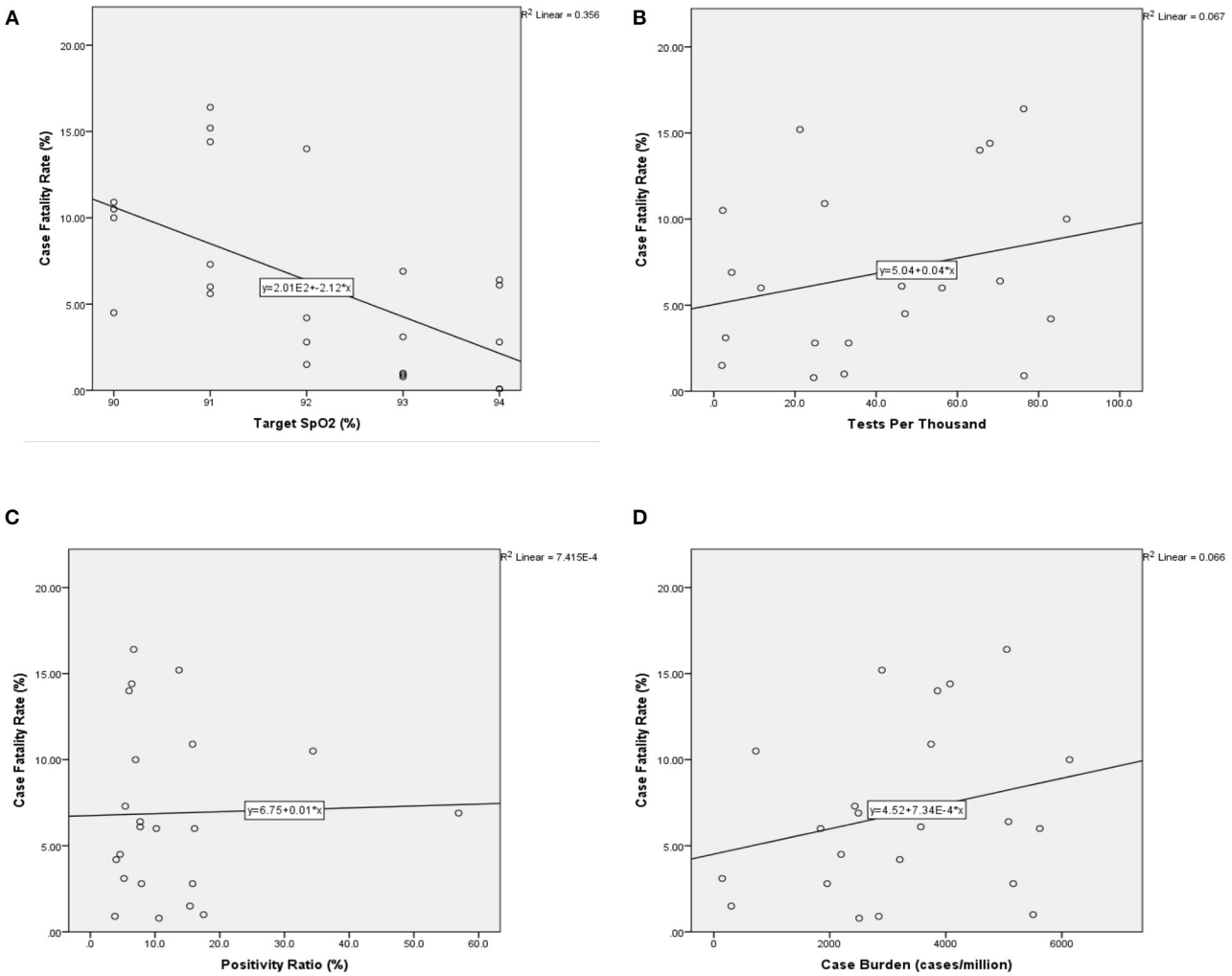

FIGURE 3 | Scatter graphs with best-fit line for primary measure and confounders vs. CFR ($N = 26$). CFR is along the vertical axis in each and measured as percentage ratio. **(A)** Comparison of national CFR vs. nationally recommended target SpO2 (%) in COVID-19. **(B)** CFR vs. burden of cases measured by total number of cases per million inhabitants. **(C)** CFR vs. Testing Rate measured by total number of tests undertaken per thousand inhabitants (tests/thousand). **(D)** CFR vs. the overall positivity ratio (%), measured as the percentage ratio of positive tests to total tests. CFR, case fatality rate; SpO_2, oxygen saturations. CFR, case fatality rate; SpO_2, oxygen saturations.

conserve oxygen simply reflects the resource limitations of the nation, and it is this resource limitation that causes an increase in mortality. For example, the UK directive to ration oxygen supply in April 2020 reduced the normal national target for the commencement of oxygen from SpO_2 of 94% to a new value of 91%. The reason for rationing was related to the surge of infections and subsequent concern over the supply of oxygen (21). If such practises are common in other nations, the relationship between national guidelines' SpO_2 and national CFR identified here may be a representation of the demands on healthcare during a surge of COVID-19 cases.

There are a number of reasons why mortality increases during a surge of infections. Patients are less likely to attend hospital or seek medical care, for fear of either contracting COVID-19 or overburdening their health service (22). Triage systems during a surge can be set with high thresholds for onward referrals (23). Another mortality factor is a potential lack of resources both staff and consumables. The overall delay to treatment that ensues prevents early correction of hypoxia, implementation of VTE (venous thromboembolism) prophylaxis, readjustment of medications (e.g., nephrotoxics) and the detection of secondary bacterial infection, and thus a likely increased mortality (24).

So then, the association between target SpO_2 and CFR identified here may be more related to target SpO_2 being an indicator of an overwhelmed healthcare service.

National Approach

The issuing of national guidelines recommending lower target oxygen saturations than would be typical for viral pneumonias (25) may relate more to the overall approach of a national

TABLE 1 | National CFR, target SpO_2, and potential testing confounders in 26 countries.

	SpO_2 (%)	Tests per thousand	Positivity ratio (%)	Case burden (cases/million)	CFR (%)
Qatar	94	82.3	25.9	20,311	0.06
Singapore	94	57.2	10.5	6,036	0.08
Pakistan	94	2.6	12.9	329	2.1
Peru	94	33.2	15.8	5,163	2.8
Switzerland	94	46.3	7.7	3,569	6.1
Ireland	94	70.6	7.7	5,080	6.4
Saudi Arabia	93	24.6	10.6	2,506	0.79
Russia	93	76.4	3.8	2,843	0.9
Chile	93	32.1	17.5	5,505	1
India	93	2.9	5.2	144	3.1
Brazil	93	4.4	56.9	2,492	6.9
Bangladesh	92	2.0	15.4	301	1.5
Turkey	92	24.9	7.9	1,955	2.8
Portugal	92	83.0	4	3,206	4.2
Iran	92	11.6	16.1	1,841	6
Italy	92	65.5	6	3,857	14
China	91	N/A	N/A	N/A	5.6
USA	91	56.2	10.2	5,620	6
Canada	91	45.7	5.4	2,431	7.3
UK	91	68.0	6.4	4,072	14.4
France	91	21.2	13.7	2,899	15.2
Belgium	91	76.3	6.7	5,051	16.4
Germany	90	47.1	4.6	2,194	4.5
Spain	90	86.9	7	6,133	10
Mexico	90	2.2	34.4	725	10.5
Sweden	90	27.3	15.8	3,746	10.9
Mean (Standard Error)	91.9 (1.32)	41.3 (28.3)	12.7 (12.1)	3,242 (1,722)	6.8 (4.8)
Correlation with CFR (Pearson's R)	**−0.53**	0.121	−0.026	−0.174	
2-tailed (*p*-value)	**<0.01**	0.57	0.91	0.42	

CFR, case fatality rate; SpO_2, oxygen saturations. Overall positivity ratio—percentage ratio of positive to total cases. Case burden—total number of positive cases per million inhabitants. Data extracted from WHO, Worldometer and John Hopkins University. Numbers in bold indicate a statistically significant result.

response to COVID-19, and as such, it is this "national approach" that relates to mortality rate.

All three investigators noted the quite different approaches between nations, as set out in their national guidelines. Some followed a "stay home" approach, whereas others defaulted to clinical assessment of patients either with COVID-19 or with any risk factor associated with it. For example, Singapore guidelines default to clinical assessment (26), whereas a country with a similar prevalence burden, the UK, has much higher thresholds for referral onward for assessment (27) (**Table 2**).

In this situation, where the national guideline target SpO_2 is part of an overall strategy of avoiding admissions, then whilst it does remain possible that conservative oxygen approaches do contribute to higher mortality, it may be the contribution of other policies to avoid admissions that leads to an increased CFR. In the UK vs. Singapore example, a target SpO_2 of <92% is likely to be harmful, but equally, failing to account for age of the patient or duration of fever may also be harmful. As such, the relationship identified here between CFR and target SpO_2 may be more a relationship between CFR and national strategy; target SpO_2 may be more of an indicator of national policy.

Limitations and Future Studies

This study highlights the variation in national guidelines for when to commence supplemental oxygen in patients with COVID-19. In of itself, this raises important questions as to the optimal response to COVID-19. Attempting to delineate the interventions and strategies that are potentially beneficial between nations is difficult without using a mortality estimation, which carries inherent confounders. CFR depends on many factors, not least of which is the accurate reporting of COVID-19-related deaths. Whilst we found no correlation between CFR and rates of testing or crude case burden, we could not account for disparities in reporting of deaths, nor did we analyse for differences in the age of the population, nor the socioeconomic status of the infected population.

TABLE 2 | Comparison of the criteria for assessment in suspected or confirmed COVID-19 between Singapore and the UK.

	Singapore	UK
Criteria for clinical assessment		
SpO_2 (%)	<95	<92
Age (yrs)	>65	Irrelevant
Comorbidity	Any	Severe
Duration of illness (days)	>3	Irrelevant
Epidemiology		
Cases/million inhabitants	6,063	4,076
Physicians/10,000 head of capita	24	28
CFR (%)	0.08	13.4

*Information is based on the clinical guidelines from each nation and WHO (see **Supplementary Material**). SpO_2–oxygen saturations. CFR, case fatality rate.*

We undertook an analysis of the national guidelines using three independent investigators. The consensus amongst the investigators supports the accuracy of the target SpO_2 extracted. The possibility remains that localities within a country, or individual doctors and nurses, chose not to follow their national guidelines. Even if such local differences were significant, the national guidelines *permit* not implementing oxygen therapy until the target oxygen level is reached; therefore, triage systems, nurses, and physicians can avoid admissions and thus limit access to supplemental oxygen. Despite the prospect of local variations in following the guidelines, the presence of the guidelines will shape and likely reflect practise nationally.

Utilising patient-specific data from cohorts from the nations analysed here would provide greater insight into whether target oxygen saturation guidelines are both being followed and having a direct impact on mortality. A further follow-up study utilising patient-specific data could help determine whether the relationship identified here is in fact causal. It would also be useful to undertake further analysis into the cost-effectiveness of increasing access to supplemental oxygen vs. expanding intensive care facilities—could more lives be saved by treating more cases earlier and with optimum oxygen targets?

CONCLUSION

There is clear disparity between national guidelines for target oxygen saturations (SpO_2) in COVID-19 across the countries analysed here. Those nations that implemented a lower target oxygen level for when to commence oxygen in patients with COVID-19 had a significantly higher CFR. Whilst there are multiple confounders to the CFR, the overall relationship between increasing CFR with a decreasing target SpO_2 warrants further investigation.

As it stands currently, our results support the position that managing COVID-19 pneumonia should not differ from the management of other pneumonias (24), insomuch as access to supplemental oxygen delivered optimally is necessary to prevent excessive mortality.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analysed in this study. This data can be found at: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200518-covid-19-sitrep-119.pdf?sfvrsn=4bd9de25_4.

AUTHOR CONTRIBUTIONS

DG and FM initially conceived of the study. HD, AK, JN, and SB contributed further to the conception and/or design of the study and contributed to the manuscript. DG, HD, and AK conducted the analysis of the national guidelines. Statistical analysis was undertaken primarily by JN. FM and DG wrote the majority of the manuscript. All contributors reviewed the final manuscript before submission.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.580585/full#supplementary-material

REFERENCES

1. *WHO Situation Report 119*. (2020). Available online at: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200518-covid-19-sitrep-119.pdf?sfvrsn=4bd9de25_4 (accessed May 20, 2020).
2. Okell LC, Verity R, Watson OJ, Mishra S, Walker P, Whittaker C, et al. Have deaths from COVID-19 in Europe plateaued due to herd immunity? *Lancet*. (2020). 395:e110–1. doi: 10.1016/S0140-6736(20)31357-X
3. Ioannidis J. The infection fatality rate of COVID-19 inferred from seroprevalence data. *medRxiv*. (2020) 99:19–33F. doi: 10.1101/2020.05.13.20101253
4. Battegay M, Kuehl R, Tschudin-Sutter S, Hirsch HH, Widmer AF, Neher RA. 2019-novel Coronavirus (2019-nCoV): estimating the case fatality rate—a word of caution. *Swiss Med Wkly*. (2020) 150:w20203. doi: 10.4414/smw.2020.20203
5. Ji Y, Ma Z, Peppelenbosch MP, Pan Q. Potential association between COVID-19 mortality and health-care resource availability. *Lancet Glob Health*. (2020) 8:e480. doi: 10.1016/S2214-109X(20)30068-1
6. Zhou F, Yu T, Du R, Fan G, Liu Y, Liu Z, et al. Clinical course and risk factors for mortality of adult inpatients with COVID-19 in Wuhan, China: a retrospective cohort study. *Lancet*. (2020) 395:1038. doi: 10.1016/S0140-6736(20)30566-3
7. Hu WP, Zhang FY, Zhang J, Hang J-Q, Zeng Y-Y, Du C-L, et al. Initial diagnosis and management of adult community-acquired pneumonia: a 5-day prospective study in Shanghai. *J Thorac Dis*. (2020) 12:1417–26. doi: 10.21037/jtd.2020.03.02
8. Blot SI, Rodriguez A, Solé-Violán J, Blanquer J, Almirall J, Rello J, et al. Effects of delayed oxygenation assessment on time to antibiotic delivery and mortality in patients with severe community-acquired pneumonia. *Crit Care Med*. (2007) 35:2509–14. doi: 10.1097/01.CCM.0000287587.43801.9C
9. Sun Q, Qiu H, Huang M, Yang Y. Lower mortality of COVID-19 by early recognition and intervention: experience from Jiangsu Province. *Ann Intensive Care*. (2020) 10:33. doi: 10.1186/s13613-020-00650-2
10. O'Driscoll BR, Howard LS, Earis J, Mak V. British Thoracic Society Emergency Oxygen Guideline Group; BTS Emergency Oxygen Guideline Development Group. BTS guideline for oxygen use in

adults in healthcare and emergency settings. *Thorax*. (2017) 72(Suppl 1):ii1–ii90. doi: 10.1136/thoraxjnl-2016-209729
11. Chu DK, Kim LH, Young PJ, Zamiri N, Almenawer SA, Jaeschke R, et al. Mortality and morbidity in acutely ill adults treated with liberal versus conservative oxygen therapy (IOTA): a systematic review and meta-analysis. *Lancet*. (2018). 391:1693–705. doi: 10.1016/S0140-6736(18)30479-3
12. Van den Boom W, Hoy M, Sankaran J, Liu M, Chahed H, Feng M, et al. The search for optimal oxygen saturation targets in critically ill patients: observational data from large ICU databases. *Chest*. (2020) 157:566–73. doi: 10.1016/j.chest.2019.09.015
13. Barrot L, Asfar P, Mauny F, Winiszewski H, Montini F, Badie J, et al. Liberal or conservative oxygen therapy for acute respiratory distress syndrome. *N Engl J Med*. (2020) 382:999–1008. doi: 10.1056/NEJMoa1916431
14. Stevens GA, Alkema L, Black RE, Boerma JT, Collins GS, Ezzati M, et al. Guidelines for accurate and transparent health estimates reporting: the GATHER statement. *Lancet*. (2016) 388:e19–23. doi: 10.1016/S0140-6736(16)30388-9
15. European Society of Respiratory Medicine. *COVID-19: Guidelines and recommendations directory*. Available online at: https://www.ersnet.org/covid-19/covid-19-guidelines-and-recommendations-directory/ (accessed on May 30, 2020).
16. United Arab Emirates Ministry of Health and Prevention. *National Guidelines for Clinical Management and Treatment of COVID-19. April 3rd*. (2020). Version 2. Available online at: https://www.dha.gov.ae/en/HealthRegulation/Documents/COVID%20National%20Guidelines%20FINAL%2018%20March.pdf (accessed May 14, 2020).
17. Fröhlich S, Boylan J, McLoughlin P. Hypoxia-induced inflammation in the lung: a potential therapeutic target in acute lung injury? *Am J Respir Cell Mol Biol*. (2013) 48:271–9. doi: 10.1165/rcmb.2012-0137TR
18. Børvik T, Evensen LH, Morelli VM, Melbye H, Brækkan SK, Hansen JB. Impact of respiratory symptoms and oxygen saturation on the risk of incident venous thromboembolism-the Tromsø study. *Res Pract Thromb Haemost*. (2020) 4:255–62. doi: 10.1002/rth2.12299
19. Goyal DK, Mansab F, Bhatti S. Room to breathe: the impact of oxygen rationing on health outcomes in SARS-CoV2. *Front Med.* (2021) 7:573037. doi: 10.3389/fmed.2020.573037
20. Brouqui P, Amrane S, Million M, Cortaredona S, Parola P, Lagier J-C, et al. Asymptomatic hypoxia in COVID-19 is associated with poor outcome. *Int J Infect Dis.* (2020) 102:233–8. doi: 10.1016/j.ijid.2020.10.067
21. NHS England. *Clinical guide for the optimal use of Oxygen therapy during the coronavirus pandemic*. (2020). Version 1. Available online at: https://www.england.nhs.uk/coronavirus/wp-content/uploads/sites/52/2020/04/C0256-specialty-guide-oxygen-therapy-and-coronavirus-9-april-2020.pdf (accessed May 14, 2020).
22. Lee SA, Mathis AA, Jobe MC, Pappalardo EA. Clinically significant fear and anxiety of COVID-19: a psychometric examination of the coronavirus anxiety scale. *Psychiatry Res*. (2020) 290:113112. doi: 10.1016/j.psychres.2020.113112
23. Steinberg E, Balakrishna A, Habboushe J, Shawl A, Lee J. Calculated decisions: COVID-19 calculators during extreme resource-limited situations. *Emerg Med Pract*. (2020) 22 (4 Suppl):CD1–5.
24. Goyal DK, Mansab F, Iqbal A, Bhatti S. Early intervention likely improves mortality in COVID-19 infection. *Clin Med*. (2020) 20:248–50. doi: 10.7861/clinmed.2020-0214
25. British Thoracic Society (2015)—*Annotated BTS Guideline for the management of CAP in adults*. (2009). Available online at: https://www.brit-thoracic.org.uk/quality-improvement/guidelines/pneumonia-adults/ (accessed May 14, 2020).
26. National Centre for Infectious Diseases (Singapore). *Interim Treatment Guidelines for COVID-19 (Version 1.0, April 2, 2020)*. Available online at: https://www.ncid.sg/Health-Professionals/Diseases-and-Conditions/Documents/Treatment%20Guidelines%20for%20COVID-19%20%282%20Apr%202020%29%20-final.pdf (accessed May 14, 2020).
27. *NICE (UK) guideline [NG165] COVID-19 rapid guideline: managing suspected or confirmed pneumonia in adults in the community* (April 3, 2020). Available online at: https://www.nice.org.uk/guidance/ng165 (accessed May 14, 2020).

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Adjusting Reported COVID-19 Deaths for the Prevailing Routine Death Surveillance in India

Hemant Deepak Shewade[1,2*†], *Giridara Gopal Parameswaran*[3†], *Archisman Mazumder*[3] *and Mohak Gupta*[3]

[1] International Union Against Tuberculosis and Lung Disease (The Union), Paris, France, [2] The Union South-East Asia Office, New Delhi, India, [3] All India Institute of Medical Sciences, New Delhi, India

In India, the "low mortality" narrative based on the reported COVID-19 deaths may be causing more harm than benefit. The extent to which COVID-19 deaths get reported depends on the coverage of routine death surveillance [death registration along with medical certification of cause of death (MCCD)] and the errors in MCCD. In India, the coverage of routine death surveillance is 18.1%. This is compounded by the fact that COVID-19 death reporting is focused among reported cases and the case detection ratio is low. To adjust for the coverage of routine death surveillance and errors in MCCD, we calculated a correction (multiplication) factor at national and state level to produce an estimated number of COVID-19 deaths. As on July 31, 2020, we calculated the infection fatality ratio (IFR) for India (0.58:100–1.16:100) using these estimated COVID-19 deaths; this is comparable with the IFR range in countries with near perfect routine death surveillance. We recommend the release of excess deaths data during COVID-19 (at least in states with high death registration) and post-mortem COVID-19 testing as a surveillance activity for a better understanding of under-reporting. In its absence, we should adjust reported COVID-19 deaths for the coverage of routine death surveillance and errors in MCCD. This way we will have a clear idea of the true burden of deaths and our public health response will never be inadequate. We recommend that "reported" or "estimated" is added before the COVID-19 death data and related indicators for better clarity and interpretation.

Keywords: coronavirus, mortality, cause of death ascertainment, death registration, missing deaths

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****Correspondence:***
Hemant Deepak Shewade
hemantjipmer@gmail.com

† These authors have contributed equally to this work and share first authorship

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BACKGROUND

On March 11, 2020, COVID-19 (a respiratory illness caused by novel coronavirus—SARS-CoV-2) was declared as a pandemic by the World Health Organization (WHO) (1, 2). Globally, as on July 31, 2020, around 675 000 people had succumbed to this disease (3). In India, the first case was reported on January 30, 2020. On July 31, 2020, the country had the third highest burden globally in terms of reported cases (1.12 million) (3). A total of 12 003 tests per million (TPM) were conducted with a test positivity rate of 6.8%. There were 35 747 reported COVID-19 deaths which translated to 26 reported COVID-19 deaths per million (DPM) (4). As per WHO and Indian Council of Medical Research (ICMR), if it is medically certified that the underlying cause of death is confirmed or suspected COVID-19, then it should be recorded and reported as a COVID-19 death (5, 6).

The case fatality ratio (CFR) measures fatality by dividing the reported COVID-19 deaths by reported COVID-19 cases. The cases are detected through surveillance (and are highly under-reported) and this crude method of calculation of mortality gives rise to variable estimates of CFR by country—from <0.1:100 to over 25:100 (7). The infection fatality ratio (IFR) is a better measure of fatality as the denominator includes total estimated infections. Both CFR and IFR can be low if under-reporting of COVID-19 deaths is high and/or only confirmed COVID-19 deaths are reported. Globally, many countries have stopped focusing on CFR as it is not a good predictor of overall mortality from SARS-CoV-2 and is not recommended for evaluation of policy or comparison across settings (7–9).

In September 2020, India was in the news for the highest number of reported COVID-19 cases per day and reached the second spot globally in terms of the cumulative reported cases (3). However, the reported COVID-19 DPM and reported CFR were low (3). The under-reporting of COVID-19 deaths could be one of the potential reasons. An editorial published in *The Lancet* (September 26, 2020) highlighted the issue of transparency of data on COVID-19 deaths in India and warned against the dangers of ensuing false optimism due to under-reporting (10).

Hence, we discuss the routine deaths surveillance in India, the rationale for adjusting the reported COVID-19 deaths for coverage of the routine death surveillance and its implications on the estimated IFR for India.

ROUTINE DEATH SURVEILLANCE IN INDIA

The civil registration system report (latest being CRS 2018, when this perspective piece was written) provides the national and state-wise coverage of death registration by dividing the registered deaths with estimated deaths (11). The national and state-wise coverage of medical certification of cause of death (MCCD) among registered deaths is provided by the MCCD report (latest being 2018, when this perspective piece was written) (12). Estimates of deaths are provided by the sample registration system where continuous enumeration of births and deaths is done in a sample of villages/urban blocks by a resident part time enumerator. This is verified by an independent six monthly retrospective survey by a full time supervisor (13).

In India, the coverage of death registration is 86% and coverage of MCCD among registered deaths in 21% (11, 12). Populous states like Uttar Pradesh, Bihar, and Jharkhand that constitute 30% of the population of India and have very low coverage of death registration (35–61%) (11). Other states with low death registration are Telangana (58%), Assam (66%), Arunachal Pradesh (48%), Manipur (28%), and Nagaland (10%) (11). Many states have 100% death registration but MCCD coverage lower than the national average (Odisha, Kerala, Rajasthan, Punjab) (11, 12).

Routine death surveillance includes death registration along with MCCD (11, 12). We multiplied the coverage of death registration among estimated deaths (source: CRS 2018) with the coverage of MCCD among registered deaths (source: MCCD 2018) to obtain the coverage of routine death surveillance (11, 12). At the national level, this was 18.1%. Therefore, the prevailing coverage of routine death surveillance in India is poor. The reason being only 34% received institutional medical attention at the time of death and not all hospitals have been brought under the coverage of MCCD (11, 12).

The state-wise coverage of routine death surveillance is depicted in **Table 1**. It was <10% in Jharkhand, Nagaland, Uttar Pradesh, Bihar, Uttarakhand, and Madhya Pradesh; 60–75% in Delhi, Chandigarh, and Puducherry; and 100% in Goa.

Among deaths undergoing registration along with MCCD, errors during MCCD are also common in developing countries like India (14–18). Therefore, the quality of MCCD is also poor.

ADJUSTING FOR ROUTINE DEATH SURVEILLANCE AND ERRORS IN MCCD

Rationale

Only a minority of all COVID-19 cases are getting recorded through testing and are reported. The second national seroprevalence survey in August–September 2020 suggested that the case detection ratio was around 6–7:100 (19). For the purpose of this exercise, as on July 31, 2020, it was assumed that the case detection ratio was at least 5:100. The extent to which COVID-19 deaths get reported among the large subset (95% or above) of unreported COVID-19 in the community depends on (i) the prevailing coverage of routine death surveillance; and (ii) extent of errors in MCCD (**Figure 1**). Within the reported COVID-19 cases also, the COVID-19 deaths could be missed due to the poor coverage of routine death surveillance and errors in MCCD. Despite WHO and ICMR guidelines (5, 6), the suspected COVID-19 deaths are not getting reported in India (20). The COVID-19 illness also presents a myriad of clinical presentations post-recovery that may lead to mortality which may not be captured by the present system in India (21).

Therefore, before we compare and interpret the differences in the reported COVID-19 deaths and the corresponding indicators of India with countries having near 100% routine death surveillance (**Supplementary Table 1**), we should adjust for the prevailing coverage and quality of routine death surveillance. This also applies to interpretation of differences across states within India.

Correction Factor for the Coverage of Routine Death Surveillance

At the national and the state level, the correction (multiplication) factor was inverse of the coverage of routine death surveillance. This factor varied from state to state. It was 5.5 nationally, (100/18.1) and ranged from 40 (100/2.5) for Jharkhand, to none (100/100) for Goa (**Table 1**). We calculated the estimated COVID-19 deaths, nationally and state wise, by multiplying the correction factor with the reported COVID-19 deaths. As on July 31, 2020, the estimated COVID-19 deaths in India were 196 997; an estimated 144 DPM **(Supplementary Table 2)**.

As on July 31, 2020, Uttar Pradesh, Madhya Pradesh, and Jharkhand were not in the top 10 states based on reported DPM. When we adjusted for routine death surveillance and calculated the estimated DPM **(Supplementary Table 2)**, they were in the top 10. The ranks of Bihar (25 to 17) and West Bengal (10

TABLE 1 | The State-wise prevailing coverage of routine death surveillance (death registration along with MCCD) and the correction factor, India (2018) (11, 12).

S. No.	States	Death registration among estimated deaths	MCCD among registered deaths	Death registration along with MCCD	Correction (multiplication) factor to adjust for routine death surveillance	Range of combined correction (multiplication) factor to adjust for routine death surveillance and errors in MCCD
		A	B	C = A*B	D = 1/(C)	Lower range = D*1, Upper range = D*2
1.	Andhra Pradesh	1.000	0.149	0.149	6.7	6.7, 13.4
2.	Telangana	0.582	0.374	0.218	4.6	4.6, 9.2
3.	Arunachal Pradesh	0.478	0.329	0.157	6.4	6.4, 12.8
4.	Assam	0.669	0.120	0.080	12.5	12.5, 25.0
5.	Bihar	0.346	0.136	0.047	21.3	21.3, 42.6
6.	Chhattisgarh	0.835	0.198	0.165	6.1	6.1, 12.2
7.	Goa	1.000	1.000	1.000	1.0	1.0, 2.0
8.	Gujarat	1.000	0.234	0.234	4.3	4.3, 8.6
9.	Haryana	1.000	0.204	0.204	4.9	4.9, 9.8
10.	Himachal Pradesh	0.839	0.150	0.126	8.0	8.0, 16.0
11.	Jharkhand	0.549	0.046	0.025	39.6	39.6, 79.2
12.	Karnataka	1.000	0.311	0.311	3.2	3.2, 6.4
13.	Kerala	1.000	0.119	0.119	8.4	8.4, 16.8
14.	Madhya Pradesh	0.788	0.105	0.083	12.1	12.1, 24.2
15.	Maharashtra	0.984	0.348	0.342	2.9	2.9, 5.8
16.	Manipur	0.375	0.514	0.193	5.2	5.2, 10.4
17.	Meghalaya	0.897	0.431	0.387	2.6	2.6, 5.2
18.	Mizoram	1.000	0.589	0.589	1.7	1.7, 3.4
19.	Nagaland	0.097	0.287	0.028	35.9	35.9, 71.8
20.	Odisha	1.000	0.111	0.111	9.0	9.0, 18.0
21.	Punjab	1.000	0.171	0.171	5.9	5.9, 11.8
22.	Rajasthan	0.999	0.131	0.131	7.6	7.6, 15.2
23.	Sikkim	1.000	0.425	0.425	2.4	2.4, 4.8
24.	Tamil Nadu	1.000	0.450	0.450	2.2	2.2, 4.4
25.	Tripura	1.000	0.223	0.223	4.5	4.5, 9.0
26.	Uttarakhand	0.707	0.111	0.078	12.7	12.7, 25.4
27.	Uttar Pradesh	0.608	0.051	0.031	32.3	32.3, 64.6
28.	West Bengal	0.918	0.129	0.118	8.4	8.4, 16.8
29.	Andaman and Nicobar	0.729	0.595	0.434	2.3	2.3, 4.6
30.	Chandigarh	1.000	0.718	0.718	1.4	1.4, 2.8
31.	Delhi	1.000	0.623	0.623	1.6	1.6, 3.2
32.	Puducherry	1.000	0.740	0.740	1.4	1.4, 2.8
33.	J&K and Ladakh	0.633	–	0.633	1.6	1.6, 3.2
34.	DNH, D&D	0.857	1.000	0.857	1.2	1.2, 2.4
35.	**India**	**0.860**	**0.210**	**0.181**	**5.5**	**5.5, 11**

MCCD, medical certification of cause of death; J and K, Jammu and Kashmir; DNH, Dadra Nagar Haveli; D and D, Daman and Diu.

**The correction factor to adjust for the prevailing routine death surveillance may be multiplied with a correction factor for errors in MCCD (we have considered an upper limit of two) to get the combined correction factor to adjust for the prevailing routine death surveillance as well as errors in MCCD. The combined correction factor could be higher than the upper range if errors in MCCD are higher than our assumptions.*

to 6) jumped upward (**Supplementary Figure 1**). Incidentally, these were the only five states that had <10 000 TPM. These five states constitute 43% of the national population. Based on reported COVID-19 deaths, these five states constituted 12% of total COVID-19 deaths but based on estimated COVID-19 deaths, they constituted 43% of the total COVID-19 deaths. The correlation coefficient (r) between TPM and coverage of routine death surveillance was 0.673 ($p < 0.001$).

As we used routine death surveillance data from 2018 and applied it to the year 2020, we also did sensitivity analysis for the correction factor by assuming different percentage increases in coverage of routine death surveillance between 2018 and

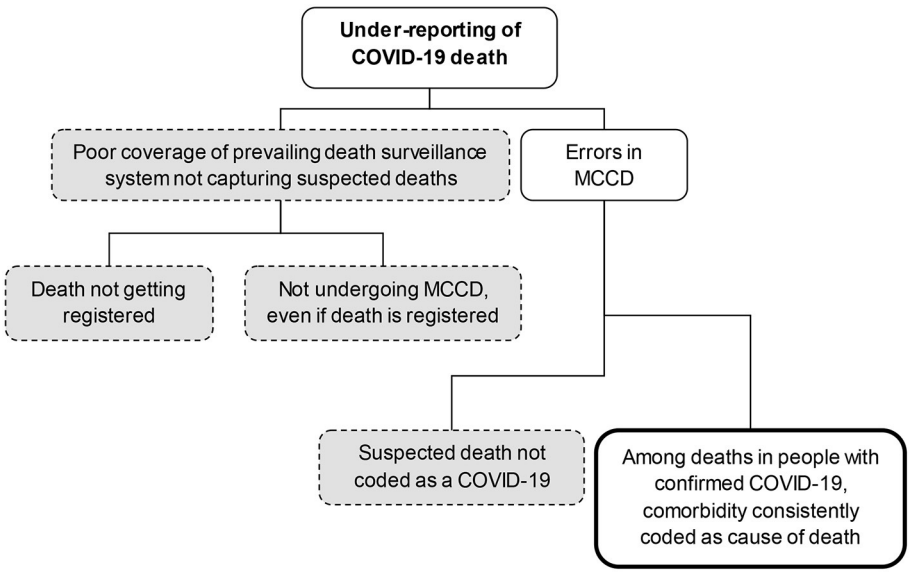

FIGURE 1 | The levels/causes of under-reporting of COVID-19 deaths*. MCCD, medical certification of cause of death. *Dotted and shaded boxes related to the under-reporting of COVID-19 deaths among non-reported cases, Bold and non-shaded box related to under-reporting among confirmed cases.

2020 (**Supplementary Table 3**). However, we do not expect any significant improvement as at the national level over the past 9 years, death registration has only increased from 67 to 86%, while the MCCD among registered deaths has been stagnant at approximately 20% (11, 12).

Correction Factor for Errors in MCCD

To adjust for under-reporting due to errors in MCCD among the deaths captured by routine death surveillance, we did not have an objective state-wise and national estimate of the error. There were state- and city-specific modeling exercises and media reports where the reported COVID-19 deaths (due to errors in MCCD) were as low as 50% (correction factor of two) of the actual deaths reported from hospitals (22, 23). We assumed two correction factors for errors in MCCD (1.5 and 2). We arrived at the estimated COVID-19 deaths after adjusting for errors in MCCD (**Supplementary Table 2**). The errors in MCCD explain why for a state like Goa with 100% routine death surveillance, under-reporting of COVID-19 deaths is still possible.

Combined Correction Factor

By multiplying the correction factor for error in MCCD and the correction factor for the prevailing routine death surveillance, we calculated a combined correction factor for the poor coverage and the quality of the routine death surveillance (**Table 1**). At the national level, the overall under-reporting could therefore possibly be by a factor as low as 5.5 (5.5*1) or as high as 11 (5.5*2) (**Table 1**). It could be higher than 11 if the upper limit for correction factor for errors in MCCD is more than two. Using a correction factor of 11, as on July 31, 2020, the estimated deaths could be as high as 393 932 (288 DPM) **(Supplementary Table 2)**. Similarly, we calculated the range of combined correction factor for states (**Table 1**).

The Estimated COVID-19 Infection Fatality Ratio in India

We created a matrix to calculate the estimated IFR for India as on July 31, 2020 taking a range of scenarios for the estimated COVID-19 deaths and the case detection ratio (**Supplementary Table 4**). With a correction factor ranging from 5.5–11 and case detection ratio of 5:100, the estimated IFR ranged from 0.58:100–1.16:100.

DISCUSSION

Key Message

We arrived at an estimate of the COVID-19 under-reporting in India using publicly available indicators regarding the coverage of routine death surveillance and some assumptions in errors in MCCD. Hence, there are two levels of under-reporting. First, COVID-19 death not being captured by routine death surveillance. Second, though the death is captured, the COVID-19 death is missed due to error in MCCD (**Figure 1**). This is also relevant for other countries with poor routine death surveillance (countries in south-east Asia and Africa). A strong positive correlation between TPM and the prevailing coverage of routine death surveillance suggests that states with weak mortality surveillance were also the ones who had conducted fewer tests.

To put the estimated COVID-19 deaths in perspective (around 200 000–400 000 as on July 31, 2020), every year there are an estimated 127 000 (95% CI: 64 046, 190 139) influenza-associated deaths in India. With respect to the under-reporting of deaths, an estimated 450 000 TB- related deaths occur annually in India which is 5.6 times the reported TB deaths (24–26).

Cannot Compare Apples With Oranges

As on July 31, 2020, of the top 10 countries (based on reported cases), eight had 90%−100% coverage of routine death surveillance (India: 18%, Peru: 57%) and all had higher reported COVID-19 DPM than India (3, 27). Small countries like the UK and Belgium with high DPM tested almost 25% of their population; have a robust routine death surveillance system and they reconcile COVID-19 deaths from their routine death surveillance system (3, 27). Other countries like Brazil, Mexico, Chile, and Peru that have a similar age distribution and socioeconomic status also have higher reported DPM when compared to India (28). The difference could be explained by their better routine death surveillance (**Supplementary Table 1**). As on May 13, 2021, when we compared with countries in south-east Asia, where most of the countries have a poor routine death surveillance (27), India had the highest reported COVID-19 DPM (3). Additional factors to consider before comparing DPM are the estimated cases based on seroprevalence surveys, death definitions used, testing strategies adopted, response to the epidemic, prevalence of comorbidities, quality of medical care, and population density.

Countries with high coverage of routine death surveillance may also miss COVID-19 deaths due to errors during MCCD or if they do not reconcile deaths from routine death surveillance. But the overall extent of under-reporting is expected to be lower when compared to countries with poor death surveillance as chances of missing deaths (irrespective of the cause) and cause-specific deaths are comparatively less due to robust mortality surveillance systems.

The COVID-19 Mortality Rate in India Is Similar to Global Figures

Using reported deaths in the numerator, the ICMR study (at around 1:100 case detection ratio in May–June) suggested the IFR to be 0.15:100 in high stratum districts and 0.01:100 in low stratum districts (29). The IFR estimated by us for India (0.58:100–1.16:100) is within the range estimated in countries with near perfect routine death surveillance (0.5:100 in Switzerland to 1.4:100 in Italy) and similar to the point estimate (0.68:100) based on a systematic review and meta-analysis (30, 31).

Other Methods to Calculate the Estimated COVID-19 Deaths

The combined correction factor provides a bird's-eye view. The best way to estimate the COVID-19 under-reporting using publicly available data would be to factor in excess deaths during the COVID-19 epidemic as compared to previous years with a sub-group analysis of age groups and cause of death (if available). The difference between excess deaths and reported COVID-19 deaths will give an idea about the possible extent of under-reporting (32). Subject to availability of granular data, exact number of excess deaths attributed to COVID-19 may be calculated by adjusting for rate of change in the number of registered deaths over the past few years, decrease in accident- and pollution-related deaths during COVID-19, and a possible increase in deaths due to disruption in routine health services. Another option is to look for excess home deaths (33). In India, the place of death (home or health facility) is a variable collected during death registration (11). The "Excess deaths" analysis is a practical option for cities, districts and states with high coverage of death registration. However, with few exceptions, the excess deaths data has not been made public like elsewhere (34, 35).

In countries with high coverage of routine death surveillance, missed suspected deaths (due to error in MCCD) can also be identified based on an increase in deaths due to pneumonia, respiratory failure, sepsis or ill-defined causes higher than the maximum limit for the number of weekly occurrences of each cause (36).

In addition to excess deaths analysis, another feasible option is post-mortem surveillance. This would mean testing all registered deaths in a surveillance area for a specific surveillance period for COVID-19 at frequent intervals. This is feasible and not resource intensive. A study from Zambia (2020) suggested that of the 364 deaths around the tertiary health facility of capital city Lusaka, 70 were COVID positive (51 in community and 19 in facility) based on post- mortem polymerase chain reaction testing. Of 70, only six were tested pre-mortem for COVID giving an under-reporting by a factor of 10 (37). Zambia has not reported the routine death surveillance coverage data to WHO indicating its routine death surveillance is poor (27).

Policy Implications

The coverage of routine death surveillance cannot be improved overnight but errors in MCCD can be prevented among the captured deaths. We can ensure that all suspected COVID-19 deaths are tested and we do not wrongly assign co-morbidity as the cause of death in confirmed COVID-19 patients.

In India, by using reported deaths to infer mortality, we are indirectly encouraging states with poor surveillance and discouraging states with relatively good surveillance. This also does not create an environment of data transparency. This false optimism of "low mortality" based on reported deaths could result in laxity among the administrators where appropriate mitigation measures may not be implemented. The health infrastructure may not be appropriately strengthened. The public health messaging based on this narrative may result in laxity among the public in following COVID19 appropriate behavior (10). The second wave that we witnessed in April–May 2021 in India could be a result of this "false optimism." This could prove to be disastrous in states with poor routine death surveillance.

The administrators (local/state/national) should be encouraged to monitor and track the estimated COVID-19 deaths and act accordingly. If the administrators act only based on the reported deaths or only when the hospital infrastructure is over-stretched (only 34% deaths happen in hospitals in India) (11), it will be too little and too late.

LIMITATIONS

There are some limitations. First, on July 31, the COVID-19 epidemic was relatively an urban phenomenon (with relatively better death surveillance) in India and our correction factor

was at state level. Therefore, our correction factor could be an overestimate and it will be more representative of the true picture as the epidemic spreads from urban to rural areas (say late 2020 and 2021). On May 13, 2021, there were 258 317 reported COVID-19 deaths (reported 186 DPM) (4). This translates to an estimated 1023–2046 DPM if we apply the combined correction factor ranging from 5.5 to 11. Second, the CRS and MCCD reports only provide state-level estimates of coverage because the sample registration system (source for the denominator in the coverage indicators) is designed to provide state-level estimates (11–13). Finally, there is an inherent limitation in the death registration coverage indicator reported by CRS. The deaths registered in CRS (numerator) are based on the place of death while the estimated deaths from sample registration system (denominator) are based on place of usual residence (11, 13).

CONCLUSION

The estimated COVID-19 deaths in India after adjusting for the coverage and quality of the routine death surveillance may be 5.5–11 times the reported COVID-19 deaths. The estimated COVID-19 deaths using IFR and DPM of India COVID-19 is comparable to the range in countries with robust death surveillance systems. Therefore, the COVID-19 fatality (rate and absolute numbers) in India does not appear to be lower than global figures.

The reported COVID-19 DPM and reported CFR/IFR of India cannot be compared with countries with robust death surveillance. We urge that "reported" or "estimated" be added before the COVID-19 death data and related indicators for better clarity and interpretation. The WHO should release country specific estimates for COVID-19 cases and deaths (like it does for other diseases); this will help in making meaningful and reliable comparisons.

In India, the epidemic is far from over and understanding the true picture of mortality will aid in eliciting an appropriate public health response and the masses adhering to the mitigation strategies (10). The "low mortality" narrative based on the reported COVID-19 deaths may be causing more harm than benefit. This should be treated as a unique window of opportunity to improve routine death surveillance.

DATA AVAILABILITY STATEMENT

The data is available on request from the corresponding author Hemant Deepak Shewade (hemantjipmer@gmail.com).

AUTHOR CONTRIBUTIONS

HS and GP conceived the idea and prepared the first draft. HS, GP, AM, and MG extracted the data. HS, GP, and AM analyzed, interpreted, and visualized the data. All authors critically reviewed the manuscript for important intellectual content and approved the final draft for submission.

SUPPLEMENTARY MATERIAL

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REFERENCES

1. Burki T. The origin of SARS-CoV-2. *Lancet Infect Dis.* (2020) 20:1018–9. doi: 10.1016/S1473-3099(20)30641-1
2. World Health Organization. WHO Director-General's opening remarks at the media briefing on COVID-19-—11 March 2020. (2020) Available online at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-$-$11-march-2020 (accessed September 23, 2020).
3. Worldometer Coronavirus. COVID-19 Coronavirus pandemic. (2020) Available online at: https://www.worldometers.info/coronavirus/ (accessed July 31, 2020 and May 13, 2021).
4. FETP Network—India. COVID-19 India. (2020) Available online at: http://covidindiaupdates.in/ (accessed July 31, 2020 and May 1 3, 2021).
5. World Health Organization (WHO). *International Guidelines for Certification and Classification (Coding) of COVID-19 as Cause of Death*. Geneva: WHO (2020).
6. ICMR National Institute of Disease Informatics and Research. *Guidance for Appropriate Recording of COVID-19 Related Deaths in India*. Bengaluru: ICMR (2020).
7. World Health Organization (WHO). *Estimating mortality from COVID-19*. (2020) Available at: https://www.who.int/publications/i/item/WHO-2019-nCoV-Sci-Brief-Mortality-2020.1 (accessed September 29, 2020).
8. Lipsitch M, Donnelly CA, Fraser C, Blake IM, Cori A, Dorigatti I, et al. Potential biases in estimating absolute and relative case-fatality risks during outbreaks. *PLoS Neglected Trop Dis.* (2015) 9:e0003846. doi: 10.1371/journal.pntd.0003846
9. Battegay M, Kuehl R, Tschudin-Sutter S, Hirsch HH, Widmer AF, Neher RA. 2019-novel Coronavirus (2019-nCoV): estimating the case fatality rate—a word of caution. *Swiss Medl Wkly.* (2020) 150:w20203. doi: 10.4414/smw.2020.20203
10. The Lancet. COVID-19 in India: the dangers of false optimism. *Lancet.* (2020) 396:867. doi: 10.1016/S0140-6736(20)32001-8
11. Office of the Registrar General of India. Ministry of Home Affairs. Government of India. *Vital Statistics of India Based on the Civil Registration System*. New Delhi: Office of the Registrar General of India (2018).
12. Office of the Registrar General of India. Ministry of Home Affairs. Government of India. *Report on Medical Certification of Cause of Death*. New Delhi: Office of the Registrar General of India (2018).
13. Office of the Registrar General & Census Commissioner India. *Sample registration system*. (2020) Available online at: https://censusindia.gov.in/vital_statistics/srs/sample_registration_system.aspx (accessed September 24, 2020).
14. Shantibala K, Akoijam BS, Usharani L, Singh HN, Laishram J, Singh TA. Death certification in a teaching hospital—a 1 year review. *Indian J Public Health.* (2009) 53:31–3.
15. Pokale A, Karmarkar MD. Knowledge of medical certificate of cause of death amongst doctors and errors in certification. *Indian J Forensic Commun Med.* (2016) 3:156. doi: 10.5958/2394-6776.2016.00035.7
16. Bhat S, Kumar VVA. Critical analysis of errors in medical certification of cause of death [MCCD] in a teaching hospital. *Int J Forensic Sci.* (2019) 4:000157. doi: 10.23880/ijfsc-16000157
17. Akakpo PK, Awuku YA, Derkyi-Kwarteng L, Gyamera KA, Eliason S. Review of errors in the issue of medical certificates of cause of death in a tertiary hospital in Ghana. *Ghana Med J.* (2017) 51:30–5. doi: 10.4314/gmj.v51i1.6

18. Maharjan L, Shah A, Shrestha KB, Shrestha G. Errors in cause-of-death statement on death certificates in intensive care unit of Kathmandu, Nepal. *BMC Health Serv Res.* (2015) 15:507. doi: 10.1186/s12913-015-1168-6
19. Indian Council of Medcal Research (ICMR). Government of India. *ICMR Second Sero Survey for SARS-CoV-2 Infection*. New Delhi: ICMR (2020).
20. Chatterjee P. Is India missing COVID-19 deaths? *Lancet.* (2020) 396:657. doi: 10.1016/S0140-6736(20)31857-2
21. Carfì A, Bernabei R, Landi F, Gemelli Against COVID-19 Post-Acute Care Study Group. Persistent symptoms in patients after acute COVID-19. *JAMA.* (2020) 324:603–5. doi: 10.1001/jama.2020.12603
22. Banaji M. Missing COVID19 fatalities in Gujarat. *Miidllesex University London.* (2020). Available online at: http://maths.mdx.ac.uk/research/modelling-the-covid-19-pandemic/missing-covid19-fatalities-in-gujarat/ (accessed September 23, 2020).
23. Saikia A. Why Assam's Covid fatality rate is lowest in India-—60% of deaths in confirmed cases not counted. *Scroll.in.* (2020) Available online at: https://scroll.in/article/972578/why-assams-covid-fatality-rate-is-lowest-in-india-60-of-deaths-in-confirmed-cases-not-counted (accessed September 23, 2020).
24. Narayan VV, Iuliano AD, Roguski K, Bhardwaj R, Chadha M, Saha S, et al. Burden of influenza-associated respiratory and circulatory mortality in India, 2010–2013. *J Glob Health.* (2020) 10:010402. doi: 10.7189/jogh.10.010402
25. World Health Organization (WHO). *Global Tuberculosis Report 2019.* Geneva: WHO (2019).
26. National TB Elimination Programme. *TB India 2020. Annual Status Report*. New Delhi: National TB Elimination Programme (2020).
27. World Health Organization (WHO). Global Health Observatory Data Repository. (2020) Available online at: https://data.worldbank.org/indicator/SP.REG.DTHS.ZS?end=2017&start=2017 (accessed November 11, 2020).
28. PopulationPyramid.net: *Population pyramids of the world from 1950 to 2100.* (2020) Available online at: https://www.populationpyramid.net/ (accessed September 23, 2020).
29. Murhekar MV, Bhatnagar T, Selvaraju S, Rade K, Saravanakumar V, Vivian Thangaraj J, et al. Prevalence of SARS-CoV-2 infection in India: Findings from the national serosurvey, May–June 2020. *Indian J Med Res.* (2020) 152:48. doi: 10.4103/ijmr.IJMR_3290_20
30. Hauser A, Counotte MJ, Margossian CC, Konstantinoudis G, Low N, Althaus CL, et al. Estimation of SARS-CoV-2 mortality during the early stages of an epidemic: A modeling study in Hubei, China, and six regions in Europe. *PLOS Med.* (2020) 17:e1003189. doi: 10.1371/journal.pmed.1003189
31. Meyerowitz-Katz G, Merone L. A systematic review and meta-analysis of published research data on COVID-19 infection-fatality rates. *Int J Infect Dis.* (2020) 101, 138–48. doi: 10.1101/2020.05.03.20089854
32. Wu J, McCann A, Katz J, Peltier E, Singh KD. 263,000 Missing Deaths: Tracking the True Toll of the Coronavirus Outbreak. *The New York Times.* (2020). Available online at: https://www.nytimes.com/interactive/2020/04/21/world/coronavirus-missing-deaths.html (accessed September 24, 2020).
33. Hogan G. After Deaths At Home Spike In NYC, Officials Plan To Count Many As COVID-19. *National Public Radio.* (2020) Available online at: https://www.npr.org/sections/coronavirus-live-updates/2020/04/08/829506542/after-deaths-at-home-in-nyc-officials-plan-to-count-many-as-covid-19 (accessed September 24, 2020).
34. Rossen LM, Branum AM, Ahmad FB, Sutton P, Anderson RN. Excess Deaths Associated with COVID-19, by Age and Race and Ethnicity—United States, January 26–October 3, 2020. *MMWR Morb Mortal Wkly Rep.* (2020) 69:1522–7. doi: 10.15585/mmwr.mm6942e2
35. Barnagarwala T. Covid outbreak: 64,349 deaths in Mumbai this year. *The Indian Express.* (2020) Available online at: https://indianexpress.com/article/cities/mumbai/covid-outbreak-64349-deaths-in-mumbai-this-year-6587188/ (accessed September 25, 2020).
36. França EB, Ishitani LH, Teixeira RA, de Abreu DMX, Corrêa PRL, Marinho F, et al. Deaths due to COVID-19 in Brazil: how many are there and which are being identified? *Revista brasileira de epidemiologia = Braz J Epidemiol.* (2020) 23:e200053. doi: 10.1590/1980-549720200053
37. Mwananyanda L, Gill CJ, MacLeod W, Kwenda G, Pieciak R, Mupila Z, et al. Covid-19 deaths in Africa: prospective systematic postmortem surveillance study. *BMJ.* (2021) 372:n334. doi: 10.1136/bmj.n334

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Rationale for Mass Masking in Controlling the COVID-19 Pandemic

Shing Yau Tam[1], *Victor C. W. Tam*[1], *Helen K. W. Law*[1], *May Ling Khaw*[2] *and Shara W. Y. Lee*[1]*

[1] Department of Health Technology and Informatics, Faculty of Health and Social Sciences, The Hong Kong Polytechnic University, Kowloon, China, [2] Tasmanian School of Medicine, University of Tasmania, Hobart, TAS, Australia

The rapid spread of the coronavirus disease 2019 (COVID-19) into a global pandemic caught the world unprepared. Previously effective measures for containing disease outbreaks were overwhelmed, necessitating strict controls such as lockdowns or curfews. Among the disease control interventions, community mass masking was one of the highly controversial issues with differing opinions on its indications or effectiveness from different health authorities around the world. Regions where community mass masking was timely introduced were associated with lower transmission rates, and more effective disease control. In this article, we discuss the evidence on the effectiveness, and rationale for community mass masking to prevent the COVID-19 transmission. Areas for further research to define the role of mass masking in light of the COVID-19 pandemic will be suggested. This would help policy makers in formulating mass masking policies.

Keywords: COVID-19, pandemic, public health, public health policy, face mask, infection control, mass masking

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***Correspondence:**
Shara W. Y. Lee
shara.lee@polyu.edu.hk

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INTRODUCTION

The coronavirus disease 2019 (COVID-19) is the result of infection by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV2), making this the third coronavirus to have crossed species and cause severe disease in humans. In the absence of effective vaccine distribution or specific antiviral agents, the only means of limiting transmission is through physical interventions such as mask wearing, physical distancing, and isolation of infectious individuals. Although the routes of transmission via respiratory droplets or aerosols and direct contact are similar to other coronaviruses, COVID-19 has defeated the control measures of many high-income nations with well-funded health infrastructures.

There are several characteristics of the COVID-19 infection that has enabled it to spread efficiently and rapidly developed into a global pandemic. COVID-19 has a wide spectrum of presentations that range from asymptomatic or having only mild symptoms, to systemic illness with multiorgan involvement (1–4). Severity of illness is generally increased in those at a more advanced age, while the younger carriers have only mild symptoms and are consequently able to spread the virus undetected. Another feature of the COVID-19 infection is the long presymptomatic phase, with a median incubation period of 5–6 days and can be as long as 19 days (5–8). Transmission can occur during the latter part of the presymptomatic phase, and 48–62% of infections were attributed to presymptomatic carriers (9). Moreover, these presymptomatic carriers were able to pass undetected through temperature screening, a previously dependable process for disease control at border checkpoints, and therefore facilitating the rapid spread globally.

As one of the key factors for limiting the transmissibility of COVID-19, community mass masking was one of the public health measures used to mitigate its rapid spread. Initially, this

practice is not universally adopted, which may account for poorer infection control outcomes for some regions (10, 11). The issue of community mass masking at the time of the emergence of COVID-19 has been highly controversial, with conflicting recommendations issued by health authorities around the world. In an earlier guideline during the spread of the pandemic from East to West, the World Health Organization (WHO) conservatively recommended against community mass masking with medical masks due to the lack of concrete evidence, while stressed on reserving the scarce resources for the healthcare workers (12). Although explicable, it seemed to reduce the chance to limit the substantial spreading of the disease in the early stage. This early recommendation was also accompanied by a speculative suggestion of risk compensation with mass masking, leading to the reduced attention in other effective protective behaviors such as performing hand hygiene (6, 12). On the contrary, Mantzari et al. (13) systematically reviewed previous studies on wearing mask with hand hygiene in community settings for controlling respiratory infections. They concluded that wearing masks did not reduce the frequency of hand sanitizing while two studies reported higher hand washing rates in the groups with mask wearing.

Notably, the recommendations on mass masking were made based on the evidence from studies on influenza outbreaks, which were not necessarily applicable to the present coronavirus. Given the little amount that was known about the COVID-19 disease and its modes of transmission, many health authorities in Asia (e.g., China, Hong Kong, Singapore etc.) exercised caution by implementing community masking recommendations (12). Subsequent recommendations based on the experience of successful control of early COVID-19 outbreaks in China also advocated for mass masking (14). Generally, Asian societies appear more inclined to wear masks voluntarily when unwell, or for protection during disease outbreaks, given the previous close encounters with epidemics such as the severe acute respiratory syndrome (SARS) in 2003 that predominantly affected Asia. Consequently, compliance with community mass masking recommendations has been high in these regions. In a global survey conducted across 15 countries during the pandemic (April 9–12, 2020) (15), countries with significant proportions of mask wearers included Vietnam (91%), China (83%), Italy (81%), Japan (77%), and India (76%). By comparison, this was lower in Western countries including United Kingdom (16%), Germany (20%), Australia (21%), Canada (28%), and France (34%).

Evidence from epidemiological data show that with a timely introduction of community mass masking in conjunction with infection prevention and control strategies were more effective in containing the COVID-19 transmission (10, 16, 17). Escalation of stricter controls such as lockdowns or curfews were subsequently not necessary (10), as exemplified in Taiwan (18). The aim of this article is to discuss the current evidence on the effectiveness, and rationale for community mass masking in preventing COVID-19 transmission. Areas for further research in order to define the role of mass masking in light of the COVID-19 pandemic will be discussed.

RATIONALE FOR MASS MASKING

Before examining the role of masks in mitigating the COVID-19 transmission, its function and basic mechanism of protection should first be considered. A mask provides a semipermeable barrier to limit the passage of particles or substance through it. The relative size of the particle to that of the pores is important. Thus, the purpose of use should be considered before a type of mask is selected. Medically speaking, surgical masks were originally used as source control to prevent contamination by droplets or aerosols containing microbes from the nose and throat of theater staff to the patient's site of operation. The use of surgical masks nowadays also protect staff from potential biohazards encountered in the operating theater, where N95 respirators are also used. Surgical masks and N95 respirators are made of high filtration materials with efficacy of $\geq$95% (0.3 μm). The protective effect of a medical mask is rated based on its filtration efficacy and the ability to provide an airtight fit to the face. When loose fitting and therefore permitting the passage of air around the edges, there is a drop in overall rated filtration efficacy to <70%, according to the US National (N10SH) N95 test (19). For this reason, the surgical mask is not classified as personal protective equipment (PPE) (20), whereas a well-fitted respirator with a N95 rating fulfills the designation of PPE due to its airtight design, and has a filtration efficacy of $\geq$95% (19).

When coughing or sneezing, aerosols, and droplet particles are exhaled, which range from 0.1 to 1,000 μm in size (11). Aerosols are particles sized <5 μm and they remain airborne for a longer period. The spread of these particles is determined by numerous factors including size, ambient temperature, air movement, and humidity. Droplets may partially evaporate, which cause them to gain more buoyancy and remain airborne for longer to spread over a greater area (11). The smaller submicron (<1 μm) aerosol particles are considered to be more dangerous as they can be inhaled and lodged deeper into the lung parenchyma, leading to more severe infections due to interference with gas exchange (20, 21).

DISCUSSION

Recent studies (21, 22) have reported that the COVID-19 virus detected in both droplets and aerosols can be propelled further than the recommended one meter of social distancing by the WHO (13, 23), or six feet recommendation by the US Centre for Disease Control and Prevention (CDC) (24).

The WHO previously recommended against wearing masks in the community due to a lack of evidence on its effectiveness. However, the evidence underlying this recommendation was drawn from 10 randomized studies on transmission of the influenza, and other human coronaviruses in the community (6).These findings could be not applicable to the transmission of a novel coronavirus which spreads more surreptitiously than influenza due to the presymptomatic carriers and those with mild symptoms that evaded detection. The basic reproductive rate of COVID-19 was estimated to be between 2.2 and 2.7 (23, 25), while the rate of the 2009 influenza H1N1 pandemic was estimated to be 1.7 (26). Subsequently in June 2020, the

WHO guideline was revised to suggest mass masking as part of the comprehensive strategy if there is limited capacity of measures in light of ongoing transmission by asymptomatic carriers in the community settings, and the potential difficulties in maintaining physical distancing and containment measures (27). The importance of mass masking in mitigating COVID-19 pandemic is summarized in **Table 1**.

Reports of transmission by asymptomatic carriers with a high viral load at the initial stage of infection emerged as early as February 2020 (5, 36), with the peak viral load occurring during symptom onset (37, 38). A recent meta-analysis of 9 published reports concluded that 15% of COVID-19 infections were asymptomatic (39), and the incubation period was reported to be 5–6 days, but can be as long as 19 days (5–8). Virus shedding in the upper respiratory tract is high among presymptomatic patients (40), while those with asymptomatic influenza usually have a lower viral load in the upper than the lower respiratory tract (41). This is the new challenge posed by the COVID-19 virus that distinguishes it from most other infectious diseases. Asymptomatic carriers were reported to play a significant role in the community spread. Li et al. (42) estimated that 86% (95% CI: 82–90%) of all infections were undocumented before travel restrictions were implemented in China. Although the transmission rate of undocumented infections was lower than the documented ones, it is estimated to be responsible for 48–62% of the COVID-19 infections (1). A recent study conducted by Hong et al. (28) reported a significantly higher incidence of COVID-19 among individuals who had close contact with presymptomatic patients without wearing masks (19.0 vs. 8.1%, $p < 0.001$).

Aerosol particles are smaller, and depending on the physical conditions such as humidity, temperature or wind, can linger in the air for considerably longer compared to droplets (20), thus enabling the virus to spread more efficiently despite physical distancing. The decay rates ranged from 0.4 to 2.27% per minute and the half-lives 30–177 min under different conditions with lower relative humidity as a factor for longer half-lives (43). Ultimately, the likelihood of infection with COVID-19 is highly dependent on the contaminating viral dose during transmission (44, 45). The rationale for mask wearing is firstly recognized as a source control to minimize the amount of virus exhaled by carriers to the atmosphere. With masking, both the amount and velocity of droplets or aerosols expelled in a breath will be smaller, thus reducing the area of spread. Secondly, the mask will protect healthy individuals from exposure to droplets or aerosols (29, 46).

Leung et al. (30) prospectively evaluated the transmission of coronavirus, influenza virus and rhinovirus in droplets and aerosols of the exhaled breath of patients with acute respiratory illnesses. They found that while only some carriers exhaled a detectable viral load, wearing a surgical mask was effective in blocking the transmission of both droplets and aerosols completely. Bae et al. (47) investigated the effectiveness of cotton and surgical masks for preventing virus shedding during coughing by COVID-19 patients. In contrast, they found that neither surgical nor cotton masks could filter the virus effectively, which was attributed to the production of aerosols when coughing. These findings suggest that although the surgical mask is adequate as a source control for asymptomatic carriers in the community, it could be less effective for those who are actively coughing. Symptomatic individuals will need testing and isolation; for source control, the N95 respirator may be required.

Meanwhile, the revised WHO guideline recommended the use of non-medical cloth or homemade masks in the community in order to preserve the stock of medical masks for healthcare workers, and recommended these as a means of source control in community settings but not for prevention (27). The guideline also suggested that wearing cloth masks on public transport, frequent hand hygiene and physical distancing should always be adopted together with cloth masks. Following the revised guideline from the WHO in June 2020 on community mass masking, many countries have adopted this recommendation. However, cloth masks may have varying filtering efficiencies, which are generally lower than that of the medical masks (48, 49). There is a lack of solid evidence to support the effectiveness of using cloth mask as a mean of source control to the asymptomatic carriers. A report conducted by Hendrix et al. (31) described 139 clients with cloth face coverings were not infected with COVID-19 after contact with two symptomatic hair stylists who also wore face coverings. The hair stylists were eventually tested positive. Yet, one laboratory study reported inferior filtering performance of general masks compared to medical masks (50). Paradoxically, the only clinical outcome study by Zhang et al. (33) reported a higher rate of respiratory illness among hospital staff wearing a cloth mask compared to not wearing a mask for protection at work. The efficacy of using cloth mask in the community setting has never been evaluated in an outcome study for COVID-19.

With the easing of lockdown in many areas, it can be seen that social distancing on its own is inadequate, and the infection rates have increased considerably. Epidemiological data from Asian regions or countries such as China, Hong Kong, Japan, Macau, Singapore, South Korea (14), Taiwan (15) where universal masking was enforced or recommended showed effective control of COVID-19 transmission, and implementation of lockdowns were limited. A number of infections occurred in bars or restaurants where masks were often removed, which emphasizes the importance of this measure (32). A recent study analyzed the trend and mitigation measures in Wuhan, Italy, and New York City from 23 January to 9 May 2020. The findings concluded that the single determinant shaping the pandemic trend was the imposition of mandatory face covering. Surprisingly, other measures such as social distancing failed to suppress transmission (33). Miyazawa et al. (34) reported a strong inverse relationship between the masking rate to the mortality rate from COVID-19; with a predictive power of 69% based on an analysis of data from 22 countries including 13 western and 9 Asian countries in March 2020. Worby and Chang (35) employed mathematical modeling to evaluate the epidemiological impact of mass masking among general population by considering resource limitations, supply and demand dynamics. They concluded that face masks can reduce total infections and deaths in COVID-19 pandemic even if the protective effect of face masks is limited. In addition, the peak time of the epidemic could be delayed. MacIntyre et al. (16) concluded in a systematic review that wearing a mask in the community was effective for both protection in crowded areas, and as a source control for COVID-19 transmission. They added

TABLE 1 | Summary of the evidence for mass masking in mitigating COVID-19 pandemic.

Evidence	Theme(s)	References
- Non-pharmaceutical interventions, including population behavioral changes in masking and social distancing, were associated with reduced transmission of COVID-19 and influenza.	A	(10)
- Community mask use by well people was suggested to offer protection to healthy individuals especially in high transmission settings.	A	(16)
- Presymptomatic transmission contributed to a significant proportion of the COVID-19 transmission. - Control strategies, such as community masking, should be adjusted to tackle presymptomatic transmission.	B	(17)
- Presymptomatic patients with mask-wearing showed significantly lower transmission to close-contact persons.	A, B	(28)
- Surgical mask partition reduced transmission of COVID-19 in a hamster model. - Reduction in transmission between the sick and the healthy groups was more significant when the surgical mask partition was placed in the sick hamsters' compartment compared to placing it in the healthy hamsters' compartment.	A	(29)
- Surgical face masks reduced viral RNA in respiratory droplets and aerosols from exhaled breath and coughs.	A, C	(30)
- Use of cloth face coverings by both symptomatic patients and healthy individual might reduce the risk of transmission.	A	(31)
- The relatively low incidence of COVID-19 in Hong Kong might be contributed by the high compliance of mass masking. - Transmission clusters in 'mask-off' settings were more prevalent than that in 'mask-on' settings.	A	(32)
- Airborne transmission was showed to be highly virulent and represented the dominant route to spread the disease in confined environment. - Social distancing alone might be insufficient in protecting the public. - Mandatory face-covering appeared to reduce transmission.	A, C	(33)
- Mask non-wearing rate was shown to be a strong predictor of the numbers of death of COVID-19 pandemic across 22 countries.	D	(34)
- Mathematical modeling evaluated that mass masking could reduce total infections and deaths in COVID-19 pandemic. Also, it could delay the peak time of the epidemic.	D, E	(35)

A, reduction in transmissibility; B, reduction in presymptomatic spread; C, reduction in droplet and aerosol transmission; D, reduction in death rate; E, delay in peak time of the epidemic.

that mass masking would be more effective if implemented early during an outbreak, which was the case for many Asian countries. Cowling et al. (10) supported this notion by suggesting that non-pharmaceutical interventions including wearing masks among citizens of Hong Kong may contribute to the suppression of local transmission of COVID-19.

A recent study conducted in Hong Kong, a population that is very compliant to community mass masking (94.8%), reported that the majority of masked individuals (83.7%) wore surgical masks. From the online questionnaire respondents, 76.3% reused their masks (51). The low infection rate at the initial stage of outbreak may imply that the reuse of surgical masks in community settings is not as harmful as anticipated, and that the benefits of masking outweigh the risks of reusing masks. A cross-sectional study in Brazil also showed similar percentage of mask reuse (71.1%) (52). However, it is notable that the efficacy or performance of reused masks is not evaluated. There was one Canadian study evaluating on the reuse of N95 respirators by autoclaving (53). Findings suggested that reusing N95 respirators was feasible in hospitals with successful reuse rate ranging from 48.8% to 79.6% in 12 sterilization cycles. The issue of early global medical mask shortage could be addressed by rationing, such as in South Korea (52) and Taiwan (53), or by the provision of free, high efficacy reusable masks in Hong Kong (54) and Singapore (54). Recently, the worldwide supply shortage of medical mask has eased considerably, and this is no longer an issue impeding the implementation of mass masking policy for transmission control in many developed countries.

FURTHER RESEARCH AND DIRECTIONS

The COVID-19 pandemic has exposed a number of weaknesses in the readiness and competence of many health authorities around the world in handling a novel infectious disease. The Chinese government resorted to the use of draconian measures to bring control to the transmission, yet many countries remained complacent and underprepared for its malignant spread. Health authorities will benefit from reviewing their capabilities in order to formulate a better epidemic response plan. Although mass masking was recommended based on lessons gained from the experience in China, this was not closely followed in many countries possibly due to the WHO's earlier guidelines against community masking. Reports of presymptomatic carriers and also transmission via aerosol route were largely disregarded. Prompt and continuous re-evaluation and adoption of newly evident recommendations by health authorities would be essential to savagely control the outbreak of the novel virus.

Future research should be directed to address these deficits. The effectiveness of repeated used cloth masks in limiting the spread of respiratory diseases, which address the shortage of disposable surgical masks. The filtration efficiency and safety test using a standardized protocol worldwide should be adopted to facilitate interpretation and comparison. The reusable copper mask that incorporates antimicrobial properties to its filter is an example of innovation, spurred by the mask shortage in Hong Kong (55). The mask complies with the American Society of Testing and Materials (ASTM) F2100 Level 1 standard and can be used in community settings. While Gilbert et al. (56) proposed an inexpensive ultraviolet system for filtering facepiece respirator decontamination that may ease the respirator demand. Efforts should be directed to the design of masks made to improve protection against aerosols that can be easily mass-produced, and safely reused by appropriate decontamination devices.

CONCLUSIONS

We have summarized and discussed the evidence on community mass masking as a public health measure for controlling the

COVID-19 transmission. Regions where mass masking was timely introduced were effective with disease control (10), potentially leading to fewer cases of mortality (57). As a source control, the surgical mask is effective, but only if carriers are asymptomatic and do not cough. With easing of lockdowns, the role of mass masking becomes more vital and remains an essential measure for controlling transmission. Lastly, the most important lesson to learn from the COVID-19 pandemic is to focus on better preparation, communication, and international cooperation to effectively limit the spread of emerging infectious diseases in the future.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

AUTHOR CONTRIBUTIONS

ST and VT performed the literature search. ST, VT, MK, and SL collected information and drafted the manuscript. SL supervised the study and edited the manuscript. ST, VT, HL, and MK edited the manuscript. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Wiersinga WJ, Rhodes A, Cheng AC, Peacock SJ, Prescott HC. Pathophysiology, transmission, diagnosis, and treatment of coronavirus disease 2019 (COVID-19): a review. *JAMA*. (2020) 324:782–93. doi: 10.1001/jama.2020.12839
2. Long B, Brady WJ, Koyfman A, Gottlieb M. Cardiovascular complications in COVID-19. *Am J Emerg Med.* (2020) 38:1504–7. doi: 10.1016/j.ajem.2020.04.048
3. Mao R, Qiu Y, He JS, Tan JY, Li XH, Liang J, et al. Manifestations and prognosis of gastrointestinal and liver involvement in patients with COVID-19: a systematic review and meta-analysis. *Lancet Gastroenterol Hepatol.* (2020) 5:667–78. doi: 10.1016/S2468-1253(20)30126-6
4. Rodriguez-Morales AJ, Cardona-Ospina JA, Gutiérrez-Ocampo E, Villamizar-Peña R, Holguin-Rivera Y, Escalera-Antezana JP, et al. Clinical, laboratory and imaging features of COVID-19: a systematic review and meta-analysis. *Travel Med Infect Dis.* (2020) 34:101623. doi: 10.1016/j.tmaid.2020.101623
5. Bai Y, Yao L, Wei T, Tian F, Jin DY, Chen L, et al. Presumed asymptomatic carrier transmission of COVID-19. *JAMA*. (2020) 323:1406–7. doi: 10.1001/jama.2020.2565
6. World Health Organization. *Advice on the Use of Masks in the Context of COVID-19: Interim Guidance 6 April 2020.* (2020). Available online at: https://apps.who.int/iris/handle/10665/331693 (accessed February 7, 2021).
7. Pan X, Chen D, Xia Y, Wu X, Li T, Ou X, et al. Asymptomatic cases in a family cluster with SARS-CoV-2 infection. *Lancet Infect Dis.* (2020) 20:410–1. doi: 10.1016/S1473-3099(20)30114-6
8. Yu P, Zhu J, Zhang Z, Han Y. A familial cluster of infection associated with the 2019 novel coronavirus indicating possible person-to-person transmission during the incubation period. *J Infect Dis.* (2020) 221:1757–61. doi: 10.1093/infdis/jiaa077
9. Ganyani T, Kremer C, Chen D, Torneri A, Faes C, Wallinga J, et al. Estimating the generation interval for COVID-19 based on symptom onset data. *medRxiv [Preprint].* (2020) 25:2000257. doi: 10.2807/1560-7917.ES.2020.25.29.2001269
10. Cowling BJ, Ali ST, Ng TWY, Tsang TK, Li JCM, Fong MW, et al. Impact assessment of non-pharmaceutical interventions against coronavirus disease 2019 and influenza in Hong Kong: an observational study. *Lancet Public Health*. (2020) 5:e279–88. doi: 10.1016/S2468-2667(20)30090-6
11. Prather KA, Wang CC, Schooley RT. Reducing transmission of SARS-CoV-2. *Science*. (2020) 368:1422–4. doi: 10.1126/science.abc6197
12. World Health Organization. *Advice on the Use of Masks the Community, During Home Care and in Health Care Settings in the Context of COVID-19: Interim Guidance 19 March 2020.* (2020). Available online at: https://apps.who.int/iris/handle/10665/331493 (accessed February 7, 2021).
13. Mantzari E, Rubin GJ, Marteau TM. Is risk compensation threatening public health in the covid-19 pandemic? *BMJ.* (2020) 370:m2913. doi: 10.1136/bmj.m2913
14. Zhang J, Litvinova M, Wang W, Wang Y, Deng X, Chen X, et al. Evolving epidemiology and transmission dynamics of coronavirus disease 2019 outside Hubei province, China: a descriptive and modelling study. *Lancet Infect Dis.* (2020) 20:793–802. doi: 10.1016/S1473-3099(20)30230-9
15. Bricker D. *More People Say They're Wearing Masks to Protect Themselves from COVID-19 Since March Paris: IPSOS.* (2020). Available online at: https://www.ipsos.com/sites/default/files/ct/news/documents/2020-04/coronavirus-wave-8-april-16-pr-ipsos.pdf (accessed April 16, 2020).
16. MacIntyre CR, Chughtai AA. A rapid systematic review of the efficacy of face masks and respirators against coronaviruses and other respiratory transmissible viruses for the community, healthcare workers and sick patients. *Int J Nurs Stud.* (2020) 108:103629. doi: 10.1016/j.ijnurstu.2020.103629
17. He X, Lau EHY, Wu P, Deng X, Wang J, Hao X, et al. Temporal dynamics in viral shedding and transmissibility of COVID-19. *Nat Med.* (2020) 26:672–5. doi: 10.1038/s41591-020-0869-5
18. Kirby J. *What We Can Learn from the "Second Wave" of Coronavirus Cases in Asia: Vox.* (2020). Available online at: https://www.vox.com/2020/4/17/21213787/coronavirus-asia-waves-hong-kong-singapore-taiwan (accessed April 17, 2020).
19. 3M Personal Safety Division. *Respirators and Surgical Masks: A Comparison*. (2020). Available online at: http://multimedia.3m.com/mws/media/957730O/respirators-and-surgical-masks-contrast-technical-bulletin.pdf (accessed May 30, 2020).
20. Tellier R, Li Y, Cowling BJ, Tang JW. Recognition of aerosol transmission of infectious agents: a commentary. *BMC Infect Dis.* (2019) 19:101. doi: 10.1186/s12879-019-3707-y
21. Buonanno G, Stabile L, Morawska L. Estimation of airborne viral emission: quanta emission rate of SARS-CoV-2 for infection risk assessment. *Environ Int.* (2020) 141:105794. doi: 10.1016/j.envint.2020.105794
22. Mittal R, Ni R, Seo J-H. The flow physics of COVID-19. *J Fluid Mech.* (2020) 894:F2. doi: 10.1017/jfm.2020.330
23. Wu JT, Leung K, Leung GM. Nowcasting and forecasting the potential domestic and international spread of the 2019-nCoV outbreak originating in Wuhan, China: a modelling study. *Lancet*. (2020) 395:689–97. doi: 10.1016/S0140-6736(20)30260-9
24. Centers for Disease Control and Prevention. *Protect Yourself.* US (2020). Available online at: https://www.cdc.gov/coronavirus/2019-ncov/prevent-getting-sick/prevention.html (accessed April 24, 2020).
25. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus-infected pneumonia. *N Engl J Med.* (2020) 382:1199–207. doi: 10.1056/NEJMoa2001316

26. Balcan D, Hu H, Goncalves B, Bajardi P, Poletto C, Ramasco JJ, et al. Seasonal transmission potential and activity peaks of the new influenza A (H1N1): a Monte Carlo likelihood analysis based on human mobility. *BMC Med.* (2009) 7:45. doi: 10.1186/1741-7015-7-45
27. World Health Organization. *Advice on the Use of Masks in the Context of COVID-19: Interim Guidance 5 June 2020.* (2020). Available online at: https://apps.who.int/iris/bitstream/handle/10665/332293/WHO-2019-nCov-IPC_Masks-2020.4-eng.pdf?sequence=1&isAllowed=y (accessed February 7, 2021).
28. Hong LX, Lin A, He ZB, Zhao HH, Zhang JG, Zhang C, et al. Mask wearing in pre-symptomatic patients prevents SARS-CoV-2 transmission: an epidemiological analysis. *Travel Med Infect Dis.* (2020) 36:101803. doi: 10.1016/j.tmaid.2020.101803
29. Chan JF-W, Yuan S, Zhang AJ, Poon VK-M, Chan CC-S, Lee AC-Y, et al. Surgical mask partition reduces the risk of non-contact transmission in a golden Syrian hamster model for coronavirus disease 2019 (COVID-19). *Clin Infect Dis.* (2020). doi: 10.1093/cid/ciaa644
30. Leung NHL, Chu DKW, Shiu EYC, Chan KH, McDevitt JJ, Hau BJP, et al. Respiratory virus shedding in exhaled breath and efficacy of face masks. *Nat Med.* (2020) 26:676–80. doi: 10.1038/s41591-020-0843-2
31. Hendrix MJ, Walde C, Findley K, Trotman R. Absence of apparent transmission of SARS-CoV-2 from two stylists after exposure at a hair salon with a universal face covering policy - Springfield, Missouri, May 2020. *MMWR Morb Mortal Wkly Rep.* (2020) 69:930–2. doi: 10.15585/mmwr.mm6928e2
32. Cheng VC, Wong SC, Chuang VW, So SY, Chen JH, Sridhar S, et al. The role of community-wide wearing of face mask for control of coronavirus disease 2019 (COVID-19) epidemic due to SARS-CoV-2. *J Infect.* (2020) 81:107–14. doi: 10.1016/j.jinf.2020.04.024
33. Zhang R, Li Y, Zhang AL, Wang Y, Molina MJ. Identifying airborne transmission as the dominant route for the spread of COVID-19. *Proc Natl Acad Sci USA.* (2020) 117:14857–63. doi: 10.1073/pnas.2009637117
34. Miyazawa D, Kaneko G. Face mask wearing rate predicts country's COVID-19 death rates. *medRxiv [Preprint].* (2020). doi: 10.1101/2020.06.22.20137745
35. Worby CJ, Chang HH. Face mask use in the general population and optimal resource allocation during the COVID-19 pandemic. *Nat Commun.* (2020) 11:4049. doi: 10.1038/s41467-020-17922-x
36. Zou L, Ruan F, Huang M, Liang L, Huang H, Hong Z, et al. SARS-CoV-2 viral load in upper respiratory specimens of infected patients. *N Engl J Med.* (2020) 382:1177–9. doi: 10.1056/NEJMc2001737
37. To KK-W, Tsang OT-Y, Yip CC-Y, Chan K-H, Wu T-C, Chan JM-C, et al. Consistent detection of 2019 novel coronavirus in saliva. *Clin Infect Dis.* (2020) 71:841–3. doi: 10.1093/cid/ciaa149
38. Wang FS, Zhang C. What to do next to control the 2019-nCoV epidemic? *Lancet.* (2020) 395:391–3. doi: 10.1016/S0140-6736(20)30300-7
39. Byambasuren O, Cardona M, Bell K, Clark J, McLaws M-L, Glasziou P. Estimating the extent of asymptomatic COVID-19 and its potential for community transmission: systematic review and meta-analysis. *medRxiv [Preprint].* (2020). doi: 10.2139/ssrn.3586675
40. Wölfel R, Corman VM, Guggemos W, Seilmaier M, Zange S, Müller MA, et al. Virological assessment of hospitalized patients with COVID-2019. *Nature.* (2020) 581:465–9. doi: 10.1038/s41586-020-2196-x
41. Ip DK, Lau LL, Leung NH, Fang VJ, Chan KH, Chu DK, et al. Viral shedding and transmission potential of asymptomatic and paucisymptomatic influenza virus infections in the community. *Clin Infect Dis.* (2017) 64:736–42. doi: 10.1093/cid/ciw841
42. Li R, Pei S, Chen B, Song Y, Zhang T, Yang W, et al. Substantial undocumented infection facilitates the rapid dissemination of novel coronavirus (SARS-CoV-2). *Science.* (2020) 368:489. doi: 10.1126/science.abb3221
43. Smither SJ, Eastaugh LS, Findlay JS, Lever MS. Experimental aerosol survival of SARS-CoV-2 in artificial saliva and tissue culture media at medium and high humidity. *Emerg Microbes Infect.* (2020) 9:1415–7. doi: 10.1080/22221751.2020.1777906
44. Dalton CB, Corbett SJ, Katelaris AL. Pre-emptive low cost social distancing and enhanced hygiene implemented before local COVID-19 transmission could decrease the number and severity of cases. *Med J Austral.* (2020) 212:1. doi: 10.2139/ssrn.3549276
45. Douglas MG, Kocher JF, Scobey T, Baric RS, Cockrell AS. Adaptive evolution influences the infectious dose of MERS-CoV necessary to achieve severe respiratory disease. *Virology.* (2018) 517:98–7. doi: 10.1016/j.virol.2017.12.006
46. Konda A, Prakash A, Moss GA, Schmoldt M, Grant GD, Guha S. Aerosol filtration efficiency of common fabrics used in respiratory cloth masks. *ACS Nano.* (2020) 14:6339–47. doi: 10.1021/acsnano.0c03252
47. Bae S, Kim M-C, Kim JY, Cha H-H, Lim JS, Jung J, et al. Effectiveness of surgical and cotton masks in blocking SARS-CoV-2: a controlled comparison in 4 patients. *Ann Int Med.* (2020) 173:W22–3. doi: 10.7326/M20-1342
48. Rengasamy S, Eimer B, Shaffer RE. Simple respiratory protection—evaluation of the filtration performance of cloth masks and common fabric materials against 20–1000 nm size particles. *Ann Occupat Hyg.* (2010) 54:789–98. doi: 10.1093/annhyg/meq044
49. Shakya KM, Noyes A, Kallin R, Peltier RE. Evaluating the efficacy of cloth facemasks in reducing particulate matter exposure. *J Expo Sci Environ Epidemiol.* (2017) 27:352–7. doi: 10.1038/jes.2016.42
50. Jung H, Kim JK, Lee S, Lee J, Kim J, Tsai P, et al. Comparison of filtration efficiency and pressure drop in anti-yellow sand masks, quarantine masks, medical masks, general masks, and handkerchiefs. *Aerosol Air Qual Res.* (2014) 14:991–1002. doi: 10.4209/aaqr.2013.06.0201
51. Tam VCW, Tam SY, Poon WK, Law HKW, Lee SWY. A reality check on the use of face masks during the COVID-19 outbreak in Hong Kong. *EClinicalMedicine.* (2020) 22:100356. doi: 10.1016/j.eclinm.2020.100356
52. Pereira-Ávila FMV, Lam SC, Góes FGB, Gir E, Pereira-Caldeira NMV, Teles SA, et al. Factors associated with the use and reuse of face masks among Brazilian individuals during the COVID-19 pandemic. *Rev Lat Am Enfermagem.* (2020) 28:e3360. doi: 10.1590/1518-8345.4604.3360
53. Czubryt MP, Stecy T, Popke E, Aitken R, Jabusch K, Pound R, et al. N95 mask reuse in a major urban hospital: COVID-19 response process and procedure. *J Hosp Infect.* (2020) 106:277–82. doi: 10.1016/j.jhin.2020.07.035
54. Government of Singapore. *How to Redeem the New Reusable Mask*. Singapore (2020). Available online at: https://www.gov.sg/article/when-should-i-wear-a-mask (accessed May 23, 2020).
55. The Government of the Hong Kong Special Administrative Region. *What Is CuMask+*. (2020). Available online at: https://www.qmask.gov.hk/about/ (accessed June 2, 2020).
56. Gilbert RM, Donzanti MJ, Minahan DJ, Shirazi J, Hatem CL, Hayward-Piatkovskyi B, et al. Mask reuse in the COVID-19 pandemic: creating an inexpensive and scalable ultraviolet system for filtering facepiece respirator decontamination. *Glob Health Sci Pract.* (2020) 8:582–95. doi: 10.9745/GHSP-D-20-00218
57. Kai D, Goldstein G-P, Morgunov A, Nangalia V, Rotkirch A. *Universal Masking Is Urgent in the COVID-19 Pandemic: SEIR and Agent Based Models, Empirical Validation, Policy Recommendations.* (2020). Available online at: https://ui.adsabs.harvard.edu/abs/2020arXiv200413553K (accessed February 7, 2021).

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Systematic Assessment of COVID-19 Pandemic in Bangladesh: Effectiveness of Preparedness in the First Wave

Priom Saha and Jahida Gulshan*

Institute of Statistical Research and Training, University of Dhaka, Dhaka, Bangladesh

Background: To develop an effective countermeasure and determine our susceptibilities to the outbreak of COVID-19 is challenging for a densely populated developing country like Bangladesh and a systematic review of the disease on a continuous basis is necessary.

Methods: Publicly available and globally acclaimed datasets (4 March 2020–30 September 2020) from IEDCR, Bangladesh, JHU, and ECDC database are used for this study. Visual exploratory data analysis is used and we fitted a polynomial model for the number of deaths. A comparison of Bangladesh scenario over different time points as well as with global perspectives is made.

Results: In Bangladesh, the number of active cases had decreased, after reaching a peak, with a constant pattern of death rate at from July to the end of September, 2020. Seventy-one percent of the cases and 77% of the deceased were males. People aged between 21 and 40 years were most vulnerable to the coronavirus and most of the fatalities (51.49%) were in the 60+ population. A strong positive correlation (0.93) between the number of tests and confirmed cases and a constant incidence rate (around 21%) from June 1 to August 31, 2020 was observed. The case fatality ratio was between 1 and 2. The number of cases and the number of deaths in Bangladesh were much lower compared to other countries.

Conclusions: This study will help to understand the patterns of spread and transition in Bangladesh, possible measures, effectiveness of the preparedness, implementation gaps, and their consequences to gather vital information and prevent future pandemics.

Keywords: COVID-19, pandemic, Bangladesh, SARS-CoV-2, first wave

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National Research Council (CNR), Italy

****Correspondence:***
Priom Saha
psaha@isrt.ac.bd

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INTRODUCTION

Severe acute respiratory syndrome coronavirus (SARS-CoV-2) causes coronavirus disease 2019, widely known as COVID-19 (1). COVID-19 is the third emergence of the virus related to severe acute respiratory syndrome (SARS). SARS in 2002–2003 and the Middle East respiratory syndrome (MERS) (2012-present) are the first two inceptions of the coronavirus disease (2). The Coronaviruses were first described in 1966 (3).

Tyrrell and Bynoe first described Coronaviruses as enveloped single-stranded large RNA viruses, those infects humans and a number of animals, and were cultivated from a high proportion of patients with cold (3). Corona is a Latin word meaning crown. With a core shell of spherical virions (entire virus particles), the coronavirus has a surface projection like a solar corona. There are mainly four subfamilies of coronaviruses (alpha, beta, gamma, and delta coronavirus). Alpha and Beta coronavirus originated from mammals (particularly Bats) and Gamma and Delta coronaviruses originated from pigs and birds. From the seven subtypes of coronavirus infecting humans, the beta-coronavirus causes serious fatalities and the gamma-coronavirus causes mild infection. SARS-Cov-2 is a type of beta-coronavirus (4).

After its first spread in Wuhan, the capital city of China's Hubei province on December 1, 2019, the infectious COVID-19 started spreading globally (4). With only one confirmed COVID-19 patient globally on 30 December 2019, the number of patients increased to 219 on 20 January 2020, and on February 24, 2020, the total number of cases increased to 79,565 cases globally. After February 2020, the exponential growth of the infectious virus is still irresistible (4, 5). On January 30, 2020, the World Health Organization (WHO) declared the outbreak a Public Health Emergency of International Concern (PHEIC) and named it a Global pandemic on March 11, 2020 (6, 7). Up to September 30, 2020, more than 214 countries and territories, and 33.5 million confirmed cases of COVID-19 have been reported all over the world (4). About 1 M deaths were caused by the virus during this period and 25.9 million people recovered from COVID-19 (4, 5, 8).

Bangladesh observed the first COVID-19 cases on March 8, 2020, as reported by the Institute of Epidemiology, Disease Control and Research (IEDCR), Bangladesh (9, 10). The country observed the first death due to Covid-19 on March 18, 2020 (9, 10). The deceased was a 70-year-old man who had comorbidities including cardiac problems, high blood pressure, kidney diseases, and diabetes (9). Bangladesh faced a total of 50,000 confirmed cases on June 1, 2020; 100,000 on the 18th of June, 150,000 on the 1st of July, 200,000 on the 17th of July, 300,000 on the 25th of August, and 350,000 confirmed cases on the 20th of September. Up to September 30, Bangladesh tested, a total of 1.95 million samples and 364.9 thousand of them were reported positive cases. A total of 277 thousand people recovered and 5,272 died of COVID-19 during that period (11).

Li et al. analyzed the first 425 cases from Wuhan, Hubei Province, China to ascertain the epidemiological characteristics of the COVID-19 patients (12). The median age of the cases was 59 years, 56% of the confirmed cases were male and the mean incubation period was 5.2 days; the elderly and the patients with other coexisting conditions had higher morbidity (12).

As an infectious disease, primarily the virus spreads between the people who are in close contact and the affected persons have some common symptoms like fever, cough, shortness of breath and loss of sense of smell, dyspnea, headache, sore throat, and rhinorrhea, etc. (13). Studies revealed that the transmission dynamics of COVID-19 is based on two mechanisms such as human to human transmission which is measured with density of population and air pollution to human which is the airborne viral infectivity. People of all ages are at risk, but elderly people and people with pre-existing medical conditions are at greater risk (14, 15). Studies found that COVID-19 related deaths are highly associated with being male, greater age, and medical conditions like diabetes, obesity, cardiovascular diseases, and severe asthma (13, 16).

Several studies reported association between COVID-19 and climatic factors (17–19). Studies showed that, environmental pollutants has significant correlation with COVID-19 patients (20, 21). Population density, temperature and absolute humidity affects the spread of the outbreak (22). A negative association was found between wind speed and covid-19 cases (23). Cities with high air pollution and high atmospheric stability has higher number of COVID patients (24, 25). Also there are apparent differences in terms of COVID-19 response among different countries probably because of their different histories, cultures and political systems and hence there is no straightforward model that could be designated as an Asian or a Western model (26, 27). Countries with low population density as well as efficient and non-corrupted progressive Governments and high health care spending achieved quicker success as compared to the countries not having such characteristics (28, 29).

At the beginning of the outbreak in Bangladesh, the country severely lacked the preparedness to tackle the spread of COVID-19 with both short and long-term implications for health as well as the economy and good governance (30) and that the health care facilities in Bangladesh are inadequate to deal with the pandemic (31). The fragile healthcare system will be in unprecedented pressure with COVID-19 pandemic, in presence of climate hazards such as floods, heat waves, etc. and disease outbreaks like dengue, cholera, and diarrhea (32). On the other hand, during an ongoing pandemic, the livelihood opportunities may reduce to a significant extent resulting in partial or complete loss of income with a significant change in the financial status or consumption behavior (33, 34). Under such circumstances, increased health care practices such as mobile sanitization, temporary quarantine sites, health care facilities, and empathic collaborations between government and locals were suggested (35) instead of a continuation of complete lockdown or shutdowns to reduce the problem.

Strong implementation of the lockdown resulted in success for several countries. New Zealand, being one of the successful eliminators of the COVID-19 pandemic, started implementing their influenza plan in early February, 2020 (36). The state of Kerala in India used their prior experience of handling the Nipah virus through extensive testing, contract testing, and community mobilization resulted in controlled spread of COVID-19 (37). Taiwan and South Korea also suppressed the COVID-19 disease successfully by quickly responding to the disease and with clear and consistent decisions to combat the threat (38).

Every outbreak and health emergencies provides a window of opportunity to gain knowledge and to develop an effective countermeasure and determine our susceptibilities to those measures. Literature shows that most of the countries that succeeded in controlling the pandemic has used their previous experience in handling the infectious disease. So a systematic review of the COVID-19 pandemic in Bangladesh on a

continuous basis is always necessary and a proper analysis of the effectiveness of the preparedness, transparency of the situation and knowledge sharing can ease out the way to make a safer future.

Unfortunately, although the first wave of Covid-19 pandemic had severe impact of health of people, a large number of countries were neither capable enough to make an efficient national planning nor timely application of the best practices for management of crisis (39). We believe that the lessons learned from the first phase of COVID-19 from the perspective of Bangladesh will be insightful while Bangladesh is experiencing another wave of Covid-19 as well as future pandemics.

What this study adds to the current literature is a systematic analysis of the overall patterns in terms of number of cases, number of deaths, and impacts of Coronavirus disease in Bangladesh, a developing country. The death patterns of Bangladesh and other countries as well as the trends over time were analyzed to compare the COVID 19 situation of Bangladesh with those countries. This study focused light on the underlying causes that resulted in a continuous outbreak. The preparedness, effectiveness of the preparedness and possible steps amid further waves are also suggested in this study.

METHODS

Sample and Data

The data for the daily tests, cases, recoveries, deaths, and age-specific death rates are collected from the daily press release of the Directorate General of Health Services, Ministry of Health & Family Welfare of Bangladesh (10). The demographic distribution of the cases is collected from The International Data Rescue (I-DARE) portal (40). The daily number of reported new cases of COVID-19 by country worldwide is collected from the European Centre for Disease Prevention and Control (ECDC) and Johns Hopkins University (JHU) database (41). The data are extracted from 4 March 2020 to 30 September 2020.

Measures of Variables

The data consists of the number of confirmed COVID-19 cases, deaths, recoveries, daily tests, total test, and demographic characteristics (Age, Sex) of the cases and deaths.

Data Analysis Procedure

Visual exploratory data analysis (V-EDA) is used to analyze the characteristics of the COVID-19 pandemic situation in Bangladesh. We have compared the situation in Bangladesh with other countries using several EDA tools such as scatter plots, histograms, bar plots, and geographical representation is shown by plotting the administrative maps using R package "mapReassy" (42). A systematic flow chart given below (**Figure 1**) summarizes the methodology of this study.

To test the inhomogeneity's in the data, in absolute homogeneity methods, we performed Normal Homogeneity Test (SNHT) (43), Buishand range test (44), Pettitt's test for single change-point detection (45), and Von Neumann ratio test (46) for number of confirmed cases and number of deaths. The alternative hypothesis, for the first three tests equals existence of a stepwise shift, whereas Von Neumann test checks the randomness in the data. The results shows the data is heterogeneous and not randomly distributed. The test results are added in the Table A3 (**Supplementary Material**).

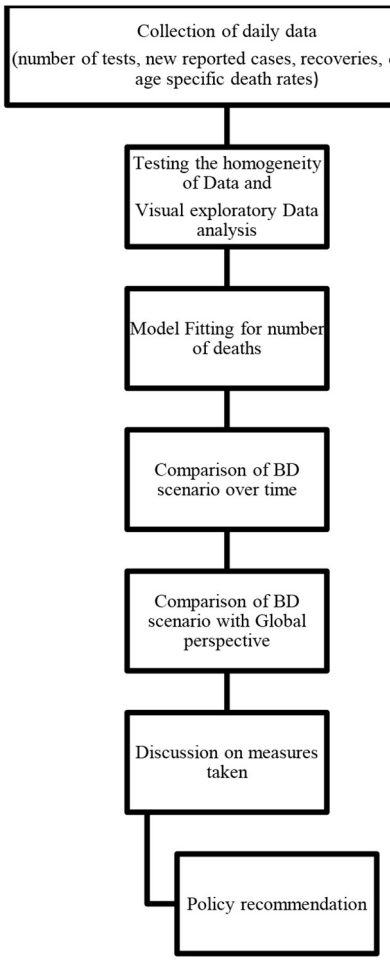

FIGURE 1 | Systematic flowchart.

Model

In absence of homogeneity, we proposed a curvilinear trend (6th order polynomial) for deaths in Bangladesh. The order of the model is selected based on goodness of fit measures. We used Akaike's Information Criteria (AIC) and Bayesian Information Criteria (BIC) to select the model.

The regression equation is given by:

$$Y = \beta_0 + \beta_1^* x + \beta_2^* x^2 + \beta_3^* x^3 + \beta_4^* x^4 + \beta_5^* x^5 + \beta_6^* x^6 \ldots . \quad (1)$$

- Y = No of deaths; x = No of days.
- The incidence rate, Case fatality are calculated as follows:
- Incidence Rate = cases *100,000 / (161.4*1,000,000)
- Case-Fatality Ratio (CFR) (%) = Number recorded deaths*100 / Number of cases.

RESULTS AND DISCUSSION

The trends in cases, recoveries, mortality, and active cases are studied thoroughly to capture the actual picture in Bangladesh. In addition to the situational reports from Bangladesh Government and the World health organization (WHO), this study highlighted the prime aspects of the first wave of COVID-19 situation in Bangladesh.

Figure 2 reflects the overall trend of COVID-19 patients in Bangladesh. Up to September 30, the total recovered patients in Bangladesh have increased resulting in a decreasing pattern in the number of active cases. The number of confirmed cases followed an increasing pattern from March to June and decreased afterward (**Figure 3**). The number of Recovered people was increasing over time from the last week of June and thereafter.

The number of COVID 19 deaths in Bangladesh has increased over time from March to mid of July (**Figure 4**). The death rate has a peak in the period from the last week of June to the second week of July with a constant pattern thereafter.

The deaths were limited in the lockdown period (26th March 2020 to 16th May 2020) and the death toll raises rapidly after that. From June to September the deaths among the younger people increased alongside the elderly deaths (**Figure 4**). The death trend in **Figure 4** are fitted using 6th order polynomial regression (Equation 1) and a detailed table is attached in the Table A3 (**Supplementary Material**).

The demographic characteristics of the COVID-19 patients indicate (**Figure 5**) that young people aged from 21 to 40 were the most affected by novel coronavirus disease and 71% of the affected were males are rest were women (29%). In the case of deaths, the elderly people (60+) were the most vulnerable and 77% of the deaths were among the male (Female 23%) (**Figure 5**).

In Bangladesh, the number of male cases outnumbered the number of female cases (Male: 71%, Female: 29%). Also the number of male deaths outnumbered the same of female deaths (Male: 77%, Female: 23%). Similar pattern was observed among the South Asian countries (for example India, Pakistan, Nepal, and Afghanistan) [a detailed table is attached in the Table A1 (**Supplementary Material**)]. Although the world data suggests both males and females are equally likely to corona-virus-disease (47). However, the gender role in mortality is also observed in SARS patients (14). In the pandemic period including the lockdown period the males more prone to roaming outside as they are the bread earners mostly, resulting exposure. Study also suggests higher tobacco consumption rate and comorbidity in males are some of the reasons (48).

The COVID-19 confirmed cases in Bangladesh were below 15% in the lockdown period (from 26th March to 16th May). From June 1 2020 to August 31 the rate remains constant at around 21%. That is, around 21 persons were tested COVID-19 positive per 100 test.This constant rate over time indicates a dubious incidence rate (**Figure 6**). Whereas, after the initial decrease of the case fatality ratio (CFR) in the lockdown period the CFR remains constant in between 1 and 2% with an average of 1.53. That is, out of 1,000 confirmed cases around 15 people die due to COVID-19 (**Figure 7**).

The statistics on the number of positive COVID cases and consequently recoveries and deaths are depending on the number of tests. In Bangladesh, the incidence rate was following a constant rate (**Figure 5**) indicating under-reported number of positive cases. High correlation (0.93) between test and positive cases indicates if the test could be conducted in higher numbers, than the actual incidence rate could have been captured (**Figure 8**).

In Bangladesh, the infectious virus spread from some particular cities (mostly Dhaka) to the whole country. While Bangladesh observed the first COVID-19 confirmed cases on March 8, 2020, on 16th April, the virus affected 44 districts out of 64 districts in Bangladesh. Dhaka and Narayanganj had the most COVID-19 positive cases (Dhaka: 608, Narayanganj: 255). Narayanganj and Dhaka worked as an epicenter for further spread in this time. On the 1st of June, the virus outspreaded mostly Cumilla, Noakhali, Chattagram, Cox's Bazar, Mymensingh, Jamalpur, Rangpur, and Sylhet. The worst-hit districts are the eastern, north-eastern, and south-eastern districts alongside Dhaka district. On the 1st of June, the spread intensified. The number of total confirmed cases increased rapidly thereafter. Upto 28th September, most of the districts have more than 2,000 confirmed COVID-19 cases (**Figure 9**).

Among the COVID-19 infected countries, Bangladesh was the 117th country in comparison to other countries considering cases per million population till September 30, 2020 [detailed figure is in Figure A1A (**Supplementary Material**)]. In terms of total cases, the USA observed the most COVID-19 positive cases and Bangladesh was the 16th country in comparison to other countries till September 30, 2020 (Figure A1B in the **Supplementary Material**). Whereas, in terms of total death per million population, Bangladesh was 111th compared to other countries (Figure A2A in the **Supplementary Material**). In comparison to the total number of deaths, the United States of America (USA) has the most deaths (2.1 million) and Bangladesh was 29th in total deaths compared to other countries till September 30, 2020 (Figure A2B in the **Supplementary Material**).

From the observed case patterns (**Figure 10A**), in the USA, Russia, and Peru the number of cases started increasing again after decreasing for a period indicating a second wave. Whereas, in Bangladesh India, Brazil, and Colombia the cases were decreasing; indicating high risk of a second wave. The graph (**Figure 10B**) shows the death pattern in the USA, Brazil, the UK, Italy, and France already reached a peak point and the death rates are decreasing over time. But in India, Mexico, and Bangladesh the death rates were still in the peak position.

Covid-19 and Measures Taken

For a developing country like Bangladesh, COVID-19 is a challenging catastrophe. Bangladesh observed its peak positions in the number of cases and deaths. The government took numerous measures to fight the COVID-19 pandemic in Bangladesh such as screening, rescuing, and lockdown, restriction on local and international air travels, and switch to online educational activities for students instead of on campus activities.

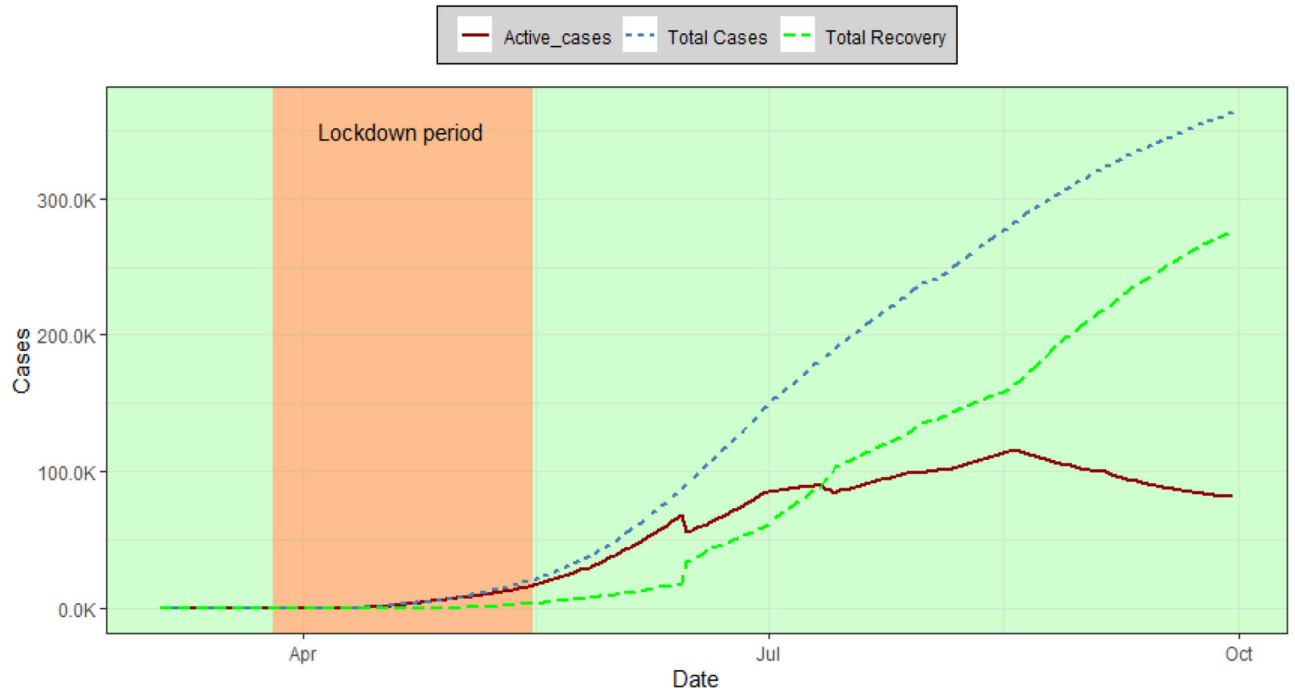

FIGURE 2 | Total cases, recovery, and active cases over time in Bangladesh.

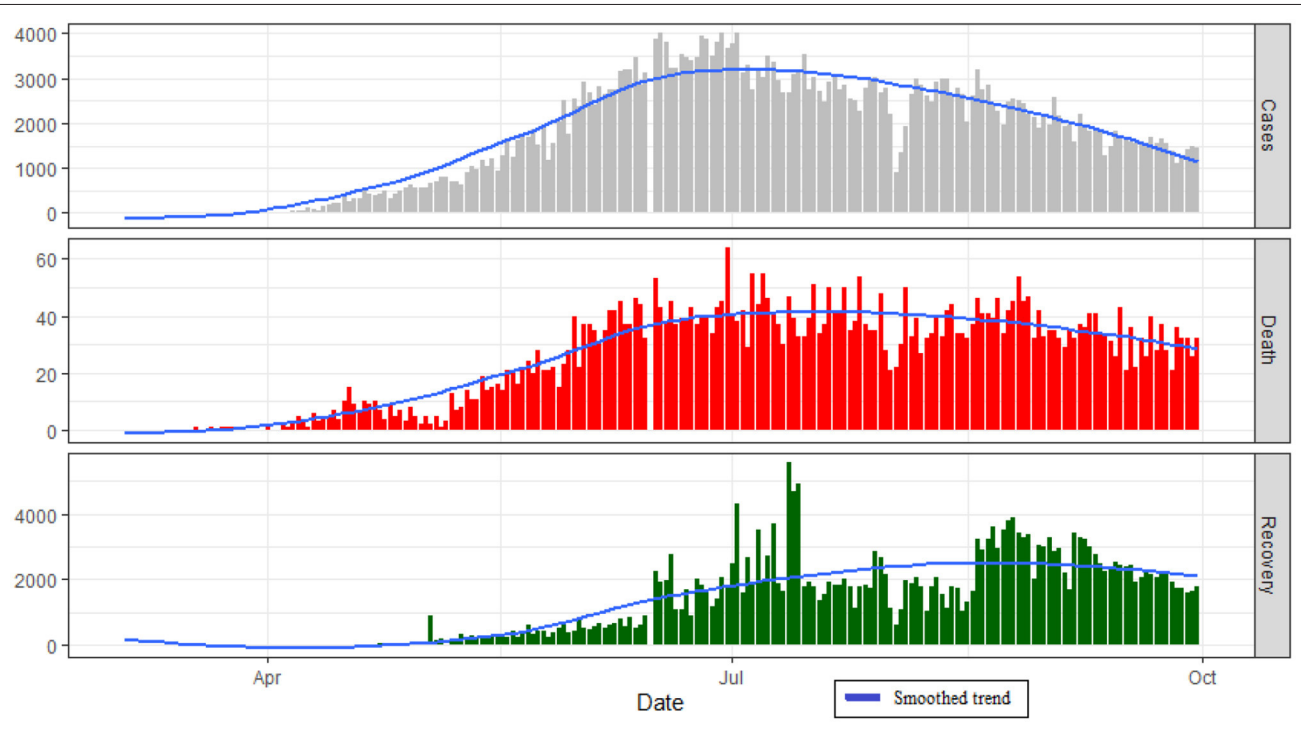

FIGURE 3 | Daily change in cases, recovery, and death in Bangladesh.

Fifty-three days after the first identification of COVID-19 in Wuhan, the Dhaka Airport authority started screening the passengers who arrived from China (49). Up to 30th September, Bangladesh has screened a total of 9,87,848 passengers. Among them, 5,61,108 are screened in the International Airports, 3,78,449 in the land ports, 41,262 in

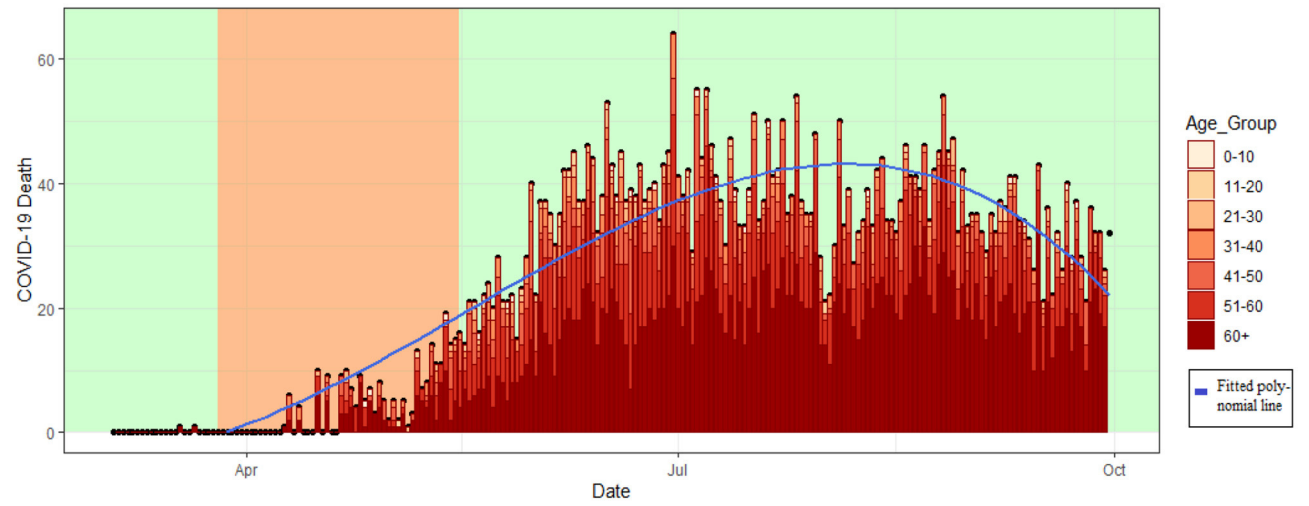

FIGURE 4 | Death trends over time in Bangladesh.

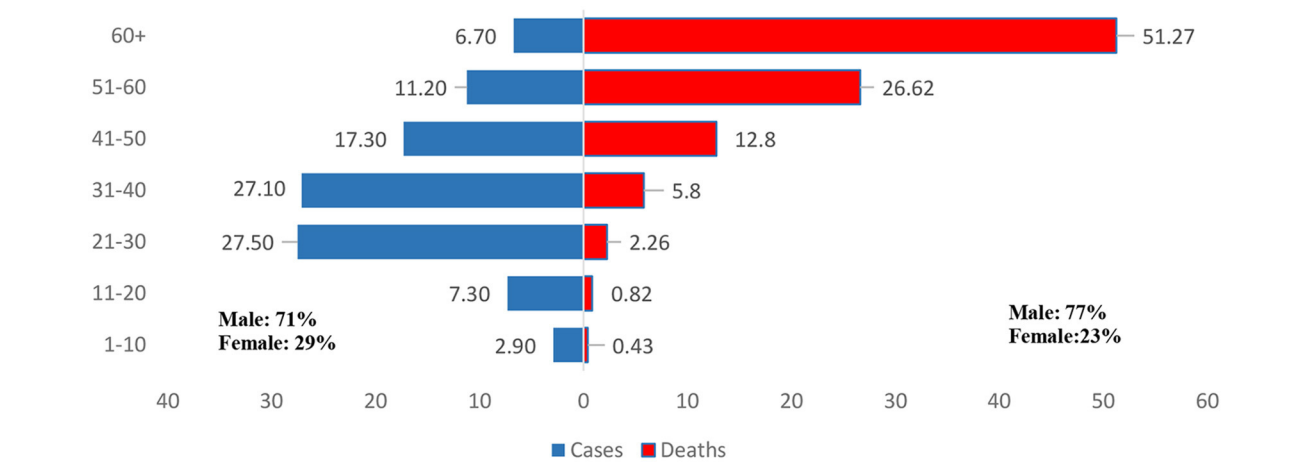

FIGURE 5 | Age distribution of cases and deaths in Bangladesh.

the seaports, and 7,029 passengers in the cantonment railway station (10).

The government rescued 312 Bangladeshi citizens from Wuhan on the 1st of February and quarantined them for 2 weeks in the Ashkona Hajj camp for 2 weeks. None of them tested positive (50, 51). On 15th March, 417 Bangladeshi returns from Italy. Two hundred seventy-five of them were kept under government supervision and 142 were sent to home quarantine (52).

Bangladesh declared the first National Preparedness and response plan for COVID-19 on 18th March (53). The first lockdown was declared on 19th March at Shibchar, Madaripur (54). On the 9th of April government imposed a complete "No entry No exist" lockdown in the Cox's Bazar District, where most of the Rohingya refugee camps are located (10, 55).

On the 23rd of March, the government ordered the closure of public and private offices from March 26 to April 4 and extended it to April 14th. On 24th March Armed forces are deployed to ensure social distancing and quarantine (10, 55). On April 10, the first general holidays are announced on April 15–23 and with several further extensions to 31st of May. On 28th May government declared the nationwide shutdown would gradually be lifted conditionally from May 31 to 15th June. All government/semi-government/Autonomous offices will be kept open to a limited extent to maintain the 13 point directive declared by DGHS (10). The transportation is also resumed on a limited scale from May 31 (10).

On 24th March a 10-day ban on all passenger travel by Air, Water, and Rail was imposed (10). Biman Bangladesh suspended all its domestic and international flights on 27th March (56). All domestic flights resumed from the 1st of June

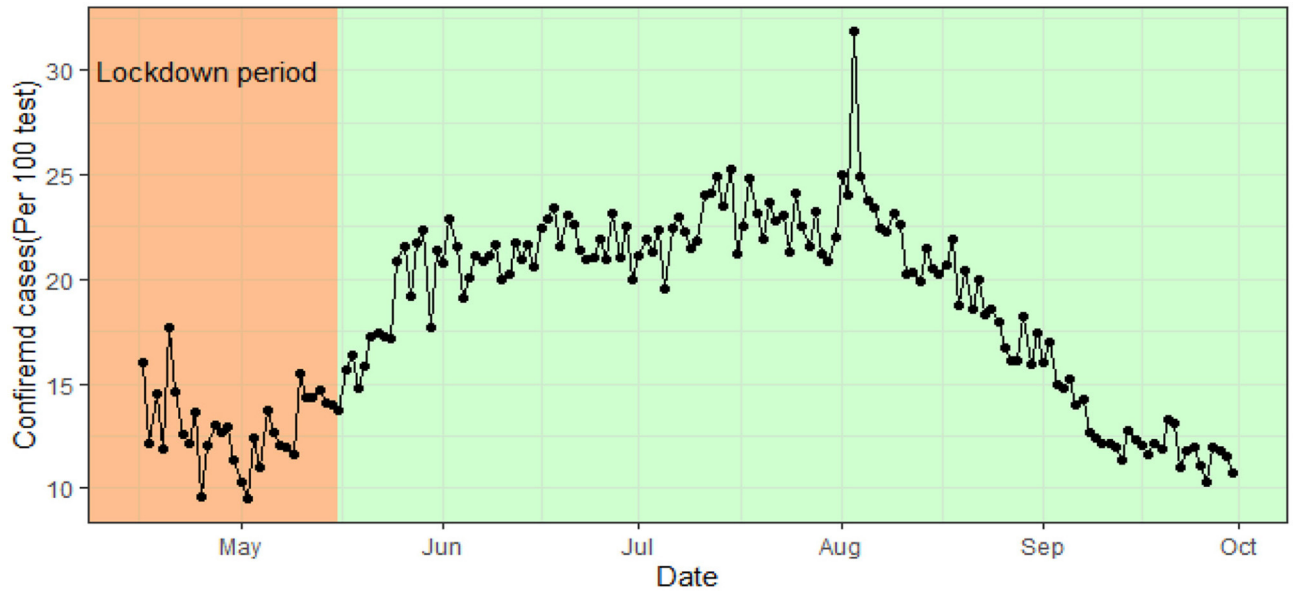

FIGURE 6 | Cases per test (100) rate in Bangladesh over time.

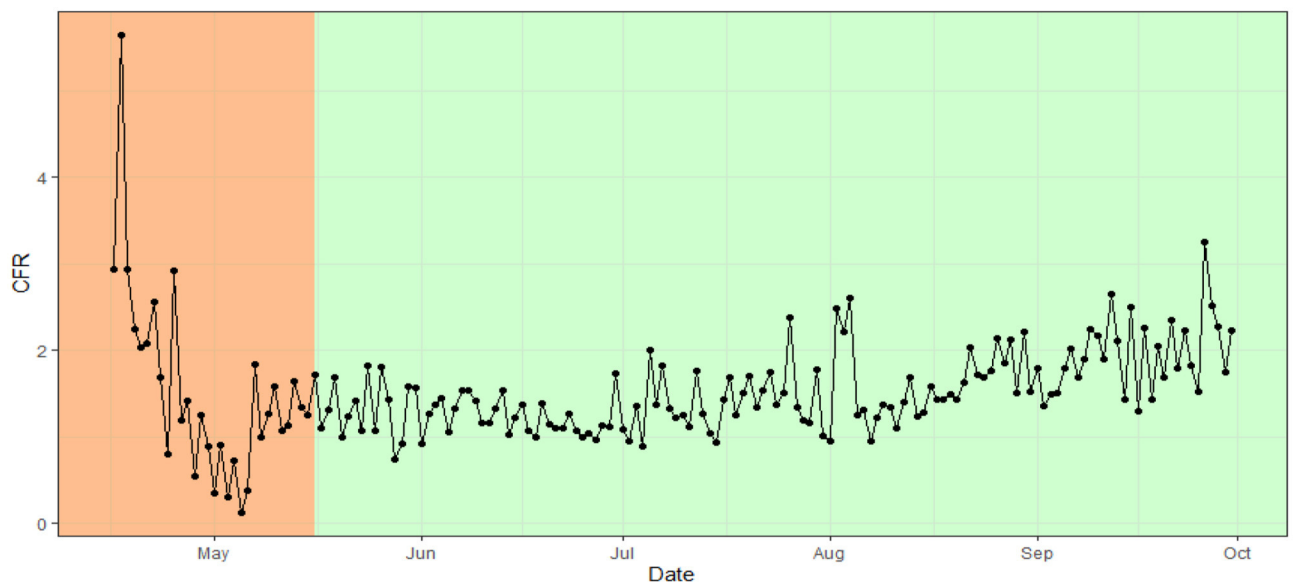

FIGURE 7 | Case fatality ratio in Bangladesh over time.

(1). Biman Bangladesh started its international flights from June 21, 2020 (52).

All the educational institutions were declared closed on 16th March. The shutdown extended several times till the 31st of October. The Government also postponed the Higher Secondary Certificate (HSC) examination on 22nd March and on 7th October the HSC and equivalent exams were declared canceled by the Educational Minister (57, 58).

The government announced a stimulus package of 8.5b USD, almost 2.5% of GDP on 5th April, 2020, amid COVID-19 impact on the economy (10). A new stimuli package of 589b USD for the agricultural sector was declared on 12th April, 2020 (10). On 20th April, 2020 Bangladesh Bank announced 30b taka lending for low-income groups (10, 55, 59).

Despite government measures, the situation in Bangladesh is deteriorating. Though some studies state that lockdown has a significant impact on reducing the spread (60), some other

showed that in general, the countries with a weak health care sector apply lockdown for longer duration but longer period of lockdown does not reduce fatality rate significantly (61) or that delaying reopening does not reduce the magnitude of the second peak of cases, but only delays it (62, 63). Studies on Bangladesh also showed that, in Bangladesh, the lockdown measures were not much effective with no sign of flattening the curve (31). Furthermore, since a longer period of lockdown has a negative impact on economic growth, it is difficult for the people of a developing country like Bangladesh to continue with lockdown for long periods (61). During ongoing pandemic livelihood opportunities has decreased and a lot of people has experienced significant or complete loss of income (34). With a significant changes in consumption pattern and financial situation (33), uncontrolled spread of the COVID-19 pandemic could leave a bulk vulnerable groups in socioeconomic crisis (64). In addition, the ongoing pandemic has a severe physiological impact across Bangladesh especially among the women and younger people (65), whereas, the older adults are more fearful of COVID-19 (66). The terminated lockdown and relaxation in other measures (such as transport restriction, mass gathering restriction, and restriction on people in the mosque at prayer, restriction in super malls, and theaters) to combat this have endangered the situation.

The mass people in Bangladesh are reluctant to the testing procedure. Since the rate of complications due to COVID-19 was low (Serious: 10–15%, Critical: 5% cases), people with moderate symptoms preferred to stay at home and avoided the tests (67). Most of them took telemedicine services from home. According to IEDCR/DGHS, up to September 30, 2020 the total number of phone calls in various hotlines (16,263, 333, and 10,655) was 21.2 million. And among them, 417, 598 receives COVID treatment (10, 40). The costly RT-PCR (3,500 tk at hospitals, 4,500 tk for samples collected from home) was one of the major reasons for the reluctance to test. Besides, the poor management in the testing booths, poor hygiene, and lack of social distancing are the key factors for the reluctance to the testing procedure. There is a firm belief that the negative people could get transmitted in the booths and they prefer not to test.

A study conducted by the IEDCR found around 45% of the Dhaka dwellers are exposed to COVID-19 and carrying antibody (40, 68, 69). Whereas, 9% (nearly 20 Lacks) could be COVID-19 positive with 78% having asymptotic patients (70). Besides 2 out of 3 slum dwellers in Dhaka and Chattagram have had COVID-19 (71). This results indicates the possibility that a small portion of the actual affected patients are reported.

However, studies showed there concern about probable under reporting bias in the COVID-19 data of Bangladesh due to resource constraints (72). Self-reported syndromic data also suggests an earlier spread of the outbreak in Bangladesh (73). Besides, study based on mortality rates found massive under reporting of confirmed cases in many countries (74). Due to limited testing capacities, confirmed cases data are not exact (74). Lack of testing kits and test facility (Lab) is one of the prior reasons for the low number of tests in the initial stage. Up to 30th May, there was only 50 lab facility for COVID testing which is 106 till now (as of 30th September). Besides, the testing facility

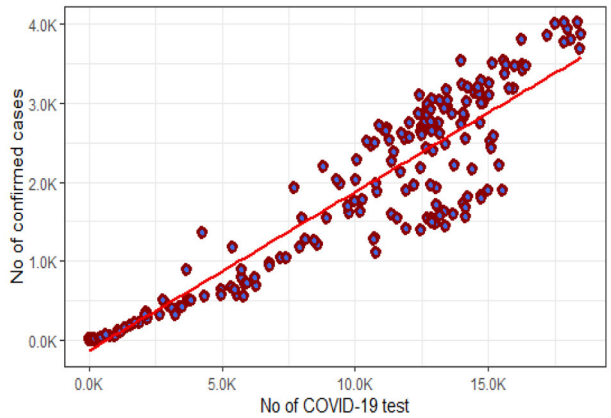

FIGURE 8 | Association between number of COVID-19 tests and confirmed cases in Bangladesh.

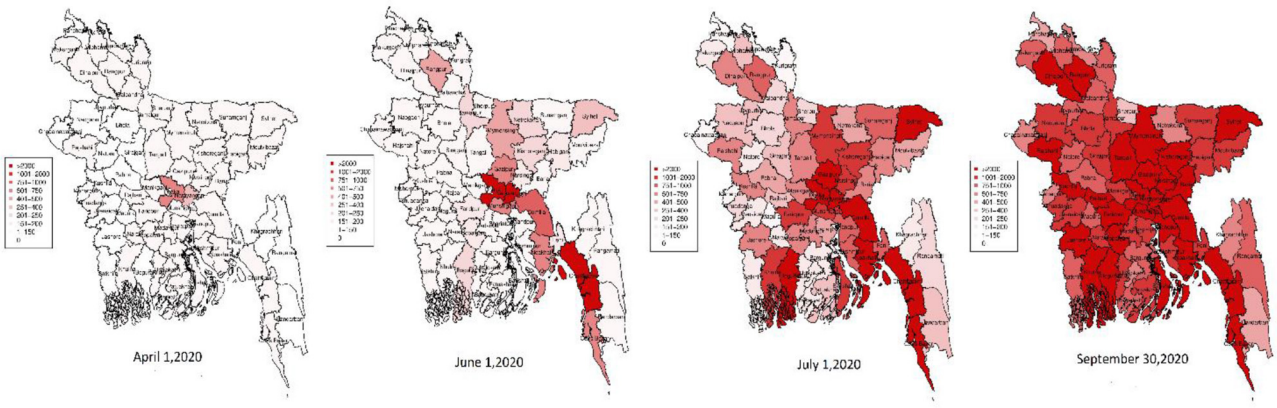

FIGURE 9 | Spread of COVID-19 positive cases in Bangladesh.

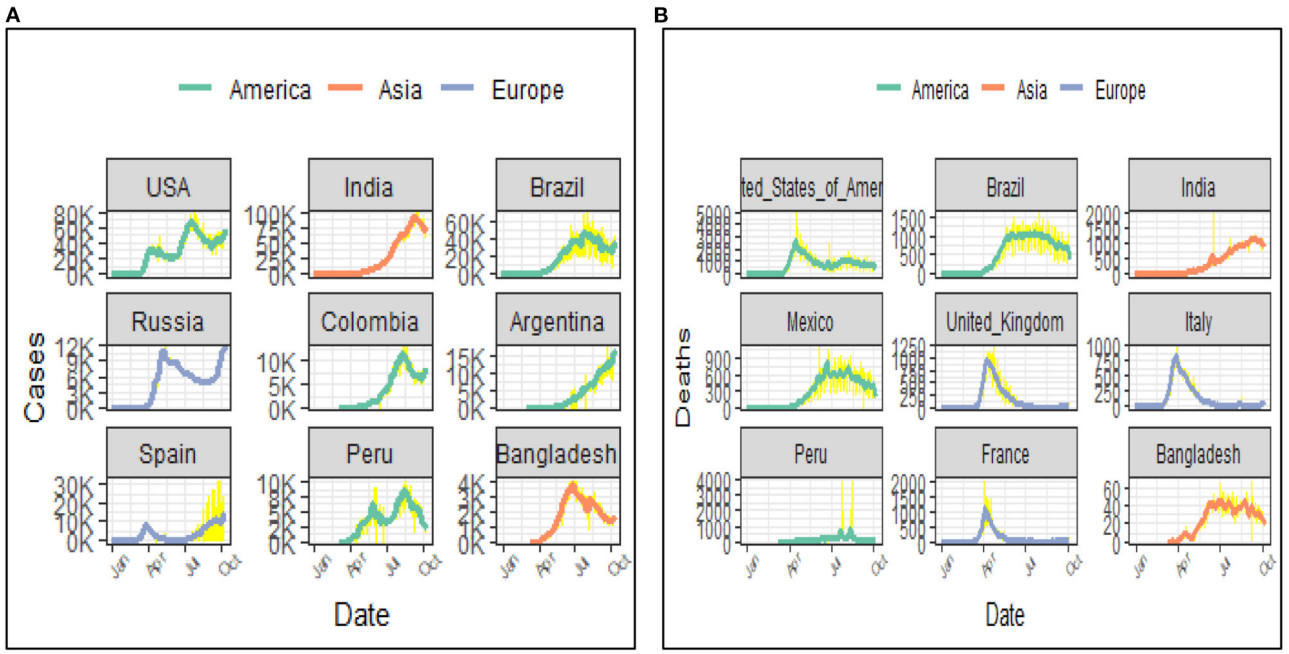

FIGURE 10 | (A) Case pattern over time (7 days average) (top 8 countries and Bangladesh). **(B)** Death pattern over time (7 days average) (top 8 countries and Bangladesh).

was mainly Dhaka concentrated initially. The first COVID testing started in IEDCR Dhaka and the government gradually increased the testing facility centering Dhaka. Among the 108 Labs, 57% of labs (60) are in Dhaka as a consequence the testing in other areas is under-reported. According to the IEDCR/DGHS, 50.11% of deaths are reported in Dhaka. Lack of awareness among the mass people and social stigma are the major reasons for low testing in Bangladesh.

In world's perspective, the incidence rate in Bangladesh compared to other countries was apparently controlled during the first wave. Bangladesh had crossed the peak period and the cases were decreasing. While after crossing first peak position, the cases in the USA, Russia, and Peru crossed/reached their second peak. Compared to them the case rates decreased in Bangladesh which was a success. The death rate in Bangladesh was also low compared to many other countries in the world during the period. The death pattern in the USA, UK, France, and Italy has crossed the peak and was moving down during June and afterwards. On the other side, Brazil, Mexico, and Bangladesh was crossing their peak time. And the death rate pattern was clustering at the peak for a large period without decreasing.

The volume of evidence during COVID 19 and at which it evolves had been a big challenge for policy makers all over the world (75). A government can break the chains of transmission and outbreaks using varying restriction policies including quarantine, social distancing, business closures or full lockdown, or a combination of any or all of these measures (38). However, keeping a balance between health and economic objectives always threw challenges to the policy makers.

Going forward, a country must examine the impact of COVID-19 in her own ability in order to continue making significant progress toward Sustainable Development Goals and solutions need to be created together with Policy makers and Public (76). And should plan to build resilient communities (77) and resilient healthcare system (76, 78).

Studies showed that, rather than a longer period of lockdown, greater healthcare expenditures (as % of GDP) can be more helpful to reduce COVID-19 fatality rates and hence an efficient strategy for future pandemics is to increase healthcare investments (61). Mathematical and computational modeling efforts have had an enormous impact on public health policy for the prevention and control of COVID-19 in the US and abroad (79, 80). However, with poor facilities of contact tracing, reluctance of people for mass testing for economic or social reasons, and insufficient investment in health care sector, it is difficult for a developing country like Bangladesh to suggest public health policies based on Mathematical or computations models due to probable underreported data.

Furthermore, studies showed concern regarding public perceptions regarding the COVID-19 pandemic because it might affect the policy makers and because of uncertainty. In addition, the "infodemic" make it even harder for the policy makers to convince people to "follow" the evidence (75). Examples of misleading advice on COVID-19 that had been rapidly and widely spread online creating threats to specific public health measures (including wearing mask or social distancing) were also true for Bangladesh (75). General people are often reluctant and ignore broad public health measures undermining COVID-19 responses.

Environmental factors should also be carefully considered in policy making for Covid-19. COVID-19 is generating substantial amounts of hazardous waste worldwide and Bangladesh is a part of it. In Bangladesh, there is an alarming unhealthy practice of collecting used mask and PPE by the waste collectors who resale it in the local market illegally as reported by the frontline newspapers and TV channels. A poor medical waste management system might increase the risk of spread of Covid-19. On the other hand, a wastewater surveillance for COVID-19 pandemic for inclusion of wastewater based epidemiology in policy making is also very important (81).

Safe mass vaccination is the long term solution for the current pandemic (82). With limited resources of health system of Bangladesh, any vaccine providing a protection, at least against severe COVID-19 cases would reduce the burden on the scanty hospital and intensive care unit facilities in the country (83, 84). Also, the mass participation to vaccination can be ensured through advertising about herd immunity (85). Fortunately Bangladesh Government has given priority to this issue and is moving forward with its vaccination strategy. With an aim of vaccinating 80% of the total adult population, the vaccination drive was inaugurated on 27th January, 2021 (86). The Bangladesh government published a priority list for the first round of vaccine recipients, including frontline workers and older people aged 40 years and above. A compulsory app-based registration system was developed for registration of vaccination against COVID-19. The vaccines, primarily, were distributed through tertiary healthcare centers in the capital city of Dhaka. Another proportion were dispersed through district hospitals and Upazila health complexes (1st referral center at primary healthcare level) (87).

In conclusion, using the lessons learned from the first wave of the crisis of COVID-19 pandemic in Bangladesh and in other countries of the world, this study suggests that, for a developing country like Bangladesh, a long period of lockdown cannot be a suitable measure to control the spread of the pandemic as it might give birth to economic crisis. Rather, social awareness regarding the spread of the disease and its probable impact, usefulness of using mask, as well as a strong healthcare sector might be helpful to fight against COVID-19.

Limitations

Our study has a few limitations. The publicly available dataset could have some misreported or under reported data. In Bangladesh data, on 15th June there is a sharp increase in the total number of recoveries due to the change in the definition of recovery by IEDCR (a patient can be declared recovered if the fever goes down without paracetamol or similar drugs and if there is a significant improvement in breathing or coughing problems within 3 days) (88). According to DGHS, over 15,000 patients recovered from COVID-19 up to June 15, 2020. The patients who recovered from COVID-19 included both symptomatic and asymptomatic patients which could not be specified due to lack of data. The deaths and recoveries occurred not only in the hospital but also at home. Lack of massive testing and lack of data on such cases, we could not shed light on that part.

CONCLUSIONS

To combat an infectious disease, it is not only important to know about the virus biology but also the nature of the spread, probable measures to prevent the disease, the effectiveness of measures, and the loopholes in those measures. In Bangladesh, the COVID-19 confirmed cases showed an exponential increase after the lockdown was relaxed.

The Government of Bangladesh had taken numerous measures to tackle the pandemic situation and consequently the spread had somewhat been controlled in Bangladesh in the first phase. However, after a long lockdown of 51 days, the "not minimized" incidence rates are probable indicators of implementation gaps of measures taken by the Government. No proper screening of the cities with international airports (Dhaka, Sylhet, and Chattagram), delay in starting screening, improper quarantine of the rescued people including the confirmed cases, lack of proper testing facilities, poor contact tracing policies were the major loopholes. In addition to that, social stigma and non-cooperation and reluctance of general people due to lack of proper knowledge regarding the spread of such an infectious disease deteriorated the situation to some extent. It is difficult to track the amount of medical waste managed properly in the current health care system of the country. However, a monitoring might improve the situation and further studies are required in this field.

The government could not succeed completely to enact the importance of the suggested guidelines to prevent the disease among the mass people. As a result, there was poor control over the implementation process to maintain the guidelines. In view of the systematic assessment of the disease in Bangladesh, we suggest that to prevent further spread, strict maintenance of the guidelines [that is, (i) Wearing mask (ii) Sanitization, (iii) Social distancing], proper lockdown policy optimized with respect to economic issues, proper screening in the ports, proper quarantine, proper medical waste management, mass testing, and finally, mass vaccination. However, mass awareness is the mandatory first step to implement any of these measures successfully. We strongly believe that these insights will assist Bangladesh as well as the other densely populated countries fighting against future pandemics.

DATA AVAILABILITY STATEMENT

Publicly available datasets were analyzed in this study. This data can be found here: https://drive.google.com/drive/folders/1nQ4SM_D97lyKehWnRmTX7y8yy9U7Qujf?usp=sharing.

ETHICS STATEMENT

Ethical review and approval was not required for the study on human participants in accordance with the local legislation and institutional requirements. Written informed consent from the participants' legal guardian/next

of kin was not required to participate in this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

JG has conceptualized the study and critically reviewed and revised the manuscript. PS collected and compiled data and drafted the manuscript. JG and PS read and approved the final manuscript. Both authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.628931/full#supplementary-material

REFERENCES

1. *Naming the Coronavirus Disease (COVID-19) and the Virus that Causes It*. Available online at: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/technical-guidance/naming-the-coronavirus-disease-(covid-2019)-and-the-virus-that-causes-it (accessed October 9, 2020).
2. Fauci AS, Lane HC, Redfield RR. Covid-19 — navigating the uncharted. *N Engl J Med*. (2020) 382:1268–9. doi: 10.1056/nejme2002387
3. Tyrrell DA, Bynoe ML. Cultivation of viruses from a high proportion of patients with colds. *Lancet*. (1966) 1:76–7.
4. *WHO Coronavirus Disease (COVID-19) Dashboard | WHO Coronavirus Disease (COVID-19) Dashboard*. Available online at: https://covid19.who.int/?gclid=EAIaIQobChMIjoSE9fan7AIVw3wrCh0afQvTEAAYASAAEgL-UfD_BwE (accessed October 9, 2020).
5. *Coronavirus Update (Live): 36,933,916 Cases and 1,069,171 Deaths from COVID-19 Virus Pandemic - Worldometer*. Available online at: https://www.worldometers.info/coronavirus/ (accessed October 9, 2020).
6. *Are People Losing Interest in Covid test? | The Business Standard*. Available online at: https://tbsnews.net/coronavirus-chronicle/covid-19-bangladesh/policy-change-single-test-covid-free-certificate-causing (accessed October 10, 2020).
7. *Statement on the Second Meeting of the International Health Regulations (2005) Emergency Committee Regarding the Outbreak of Novel Coronavirus (2019-nCoV)*. Available online at: https://www.who.int/news/item/30-01-2020-statement-on-the-second-meeting-of-the-international-health-regulations-(2005)-emergency-committee-regarding-the-outbreak-of-novel-coronavirus-(2019-ncov) (accessed November 1, 2020).
8. *Bangladesh Goverement Update on COVID-19 (1st October)*. (2020) Available online at: https://corona.gov.bd/storage/press-releases/October2020/GMrR2Bz4wMJmiYvr1mAB.pdf (accessed November 1, 2020).
9. *COVID-19 General Information | IEDCR*. Available online at: https://iedcr.gov.bd/covid-19/covid-19-general-information (accessed October 9, 2020).
10. *Coronavirus Disease 2019 (COVID-19) Information Bangladesh | corona.gov.bd*. Available online at: https://corona.gov.bd/press-release (accessed October 6, 2020).
11. *Coronavirus Disease 2019 (COVID-19) Information Bangladesh | corona.gov.bd*. Available online at: https://corona.gov.bd/patient-report (accessed October 9, 2020).
12. Li Q, Guan X, Wu P, Wang X, Zhou L, Tong Y, et al. Early transmission dynamics in Wuhan, China, of novel coronavirus–infected pneumonia. *N Engl J Med*. (2020) 382:1199–207. doi: 10.1056/nejmoa2001316
13. Williamson EJ, Walker AJ, Bhaskaran K, Bacon S, Bates C, Morton CE, et al. Factors associated with COVID-19-related death using OpenSAFELY. *Nature*. (2020) 584:430–6. doi: 10.1038/s41586-020-2521-4
14. Jin JM, Bai P, He W, Wu F, Liu XF, Han DM, et al. Gender differences in patients with COVID-19: focus on severity and mortality. *Front Public Heal*. (2020) 8:152. doi: 10.3389/fpubh.2020.00152
15. Sarkodie SA, Owusu PA. Global effect of city-to-city air pollution, health conditions, climatic & socio-economic factors on COVID-19 pandemic. *Sci Total Environ*. (2021) 778:146394. doi: 10.1016/j.scitotenv.2021.146394
16. Sunyer J, Dadvand P, Foraster M, Gilliland F, Nawrot T. Environment and the COVID-19 pandemic. *Environ Res*. (2021) 195:110819. doi: 10.1016/j.envres.2021.110819
17. Liu J, Zhou J, Yao J, Zhang X, Li L, Xu X, et al. Impact of meteorological factors on the COVID-19 transmission: a multi-city study in China. *Sci Total Environ*. (2020) 726:138513. doi: 10.1016/j.scitotenv.2020.138513
18. Xie J, Zhu Y. Association between ambient temperature and COVID-19 infection in 122 cities from China. *Sci Total Environ*. (2020) 724:138201. doi: 10.1016/j.scitotenv.2020.138201
19. Ma Y, Zhao Y, Liu J, He X, Wang B, Fu S, et al. Effects of temperature variation and humidity on the death of COVID-19 in Wuhan, China. *Sci Total Environ*. (2020) 724: 138226. doi: 10.1016/j.scitotenv.2020.138226
20. Bashir MF, Ma BJ, Bilal, Komal B, Bashir MA, Farooq TH, et al. Correlation between environmental pollution indicators and COVID-19 pandemic: a brief study in Californian context. *Environ Res*. (2020) 187:109652. doi: 10.1016/j.envres.2020.109652
21. Coccia M. An index to quantify environmental risk of exposure to future epidemics of the COVID-19 and similar viral agents: theory and practice. *Environ Res*. (2020) 191:110155. doi: 10.1016/j.envres.2020.110155
22. Diao Y, Kodera S, Anzai D, Gomez-Tames J, Rashed EA, Hirata A. Influence of population density, temperature, and absolute humidity on spread and decay durations of COVID-19: a comparative study of scenarios in China, England, Germany, and Japan. *One Heal*. (2021) 12:100203. doi: 10.1016/j.onehlt.2020.100203
23. Islam N, Bukhari Q, Jameel Y, Shabnam S, Erzurumluoglu AM, Siddique MA, et al. COVID-19 and climatic factors: a global analysis. *Environ Res*. (2021) 193:110355. doi: 10.1016/j.envres.2020.110355
24. Coccia M. Effects of the spread of COVID-19 on public health of polluted cities: results of the first wave for explaining the dejà vu in the second wave of COVID-19 pandemic and epidemics of future vital agents. *Environ Sci Pollut Res*. (2021) 28:19147–54. doi: 10.1007/s11356-020-11662-7
25. Coccia M. The effects of atmospheric stability with low wind speed and of air pollution on the accelerated transmission dynamics of COVID-19. *Int J Environ Stud*. (2021) 78:1–27. doi: 10.1080/00207233.2020.1802937
26. Abuza Z. *Explaining Successful (and Unsuccessful) COVID-19 Responses in Southeast Asia*. Diplomat. (2020). p. 1–11. Available online at: https://thediplomat.com/2020/04/explaining-successful-and-unsuccessful-covid-19-responses-in-southeast-asia/ (accessed July 27, 2021).
27. Ritchie H, Ortiz-Ospina E, Beltekian D, Mathieu E, Hasell J, Macdonald B, et al. *Coronavirus Pandemic (COVID-19)*. Our World Data. (2020). Available online at: https://ourworldindata.org/coronavirus (accessed July 20, 2021).
28. Anttiroiko AV. Successful government responses to the pandemic: contextualizing national and urban responses to the COVID-19 outbreak in east and west. *Int J E-Planning Res*. (2021) 10:1–17. doi: 10.4018/IJEPR.20210401.oa1
29. Coccia M. High health expenditures and low exposure of population to air pollution as critical factors that can reduce fatality rate in COVID-19 pandemic crisis: a global analysis. *Environ Res*. (2021) 199:111339. doi: 10.1016/j.envres.2021.111339
30. Biswas RK, Huq S, Afiaz A, Khan HTA. A systematic assessment on COVID-19 preparedness and transition strategy in Bangladesh. *J Eval Clin Pract*. (2020) 26:1599–611. doi: 10.1111/jep.13467
31. Bodrud-Doza M, Shammi M, Bahlman L, Islam ARMT, Rahman MM. Psychosocial and socio-economic crisis in bangladesh due to COVID-19 pandemic: a perception-based assessment. *Front Public Health*. (2020) 8:341. doi: 10.3389/fpubh.2020.00341

32. Rahman MM, Bodrud-Doza M, Shammi M, Md Towfiqul Islam AR, Moniruzzaman Khan AS. COVID-19 pandemic, dengue epidemic, and climate change vulnerability in Bangladesh: scenario assessment for strategic management and policy implications. *Environ Res.* (2021) 192:110303. doi: 10.1016/j.envres.2020.110303
33. Hasan S, Islam MA, Bodrud-Doza M. Crisis perception and consumption pattern during COVID-19: do demographic factors make differences? *Heliyon*. (2021) 7:e07141. doi: 10.1016/j.heliyon.2021.e07141
34. Ruszczyk HA, Rahman MF, Bracken LJ, Sudha S. Contextualizing the COVID-19 pandemic's impact on food security in two small cities in Bangladesh. *Environ Urban*. (2021) 33:239–54. doi: 10.1177/0956247820965156
35. Anwar S, Nasrullah M, Hosen MJ. COVID-19 and Bangladesh: challenges and how to address them. *Front Public Heal.* (2020) 8:1–8. doi: 10.3389/fpubh.2020.00154
36. Baker MG, Wilson N, Anglemyer A. Successful elimination of covid-19 transmission in New Zealand. *N Engl J Med.* (2020) 383:e56. doi: 10.1056/NEJMc2025203
37. The Lancet. India under COVID-19 lockdown. *Lancet*. (2020) 395:1315. doi: 10.1016/S0140-6736(20)30938-7
38. Atalan A. Is the lockdown important to prevent the COVID-9 pandemic? Effects on psychology, environment and economy-perspective. *Ann Med Surg.* (2020) 56:38–42. doi: 10.1016/j.amsu.2020.06.010
39. Coccia M. The impact of first and second wave of the COVID-19 pandemic in society: comparative analysis to support control measures to cope with negative effects of future infectious diseases. *Environ Res.* (2021) 197:111099. doi: 10.1016/j.envres.2021.111099
40. IEDCR. Available online at: http://old.iedcr.gov.bd/ (accessed October 6, 2020).
41. *Download the Daily Number of New Reported Cases of COVID-19 by Country Worldwide*. Available online at: https://www.ecdc.europa.eu/en/publications-data/download-todays-data-geographic-distribution-covid-19-cases-worldwide (accessed October 6, 2020).
42. Lawson AB. Disease map reconstruction. *Stat Med*. (2001) 20:2183–204. doi: 10.1002/sim.933
43. Alexandersson H. A homogeneity test applied to precipitation data. *J Climatol.* (1986) 6:661–75. doi: 10.1002/joc.3370060607
44. Buishand TA. Some methods for testing the homogeneity of rainfall records. *J Hydrol.* (1982) 58:11–27. doi: 10.1016/0022-1694(82)90066-X
45. Pettitt AN. A non-parametric approach to the change-point problem. *Appl Stat*. (1979) 28:126. doi: 10.2307/2346729
46. von Neumann J. Distribution of the ratio of the mean square successive difference to the variance. *Ann Math Stat*. (1941) 12:367–95. doi: 10.1214/aoms/1177731677
47. *The COVID-19 Sex-Disaggregated Data Tracker | Global Health 50/50*. Available online at: https://globalhealth5050.org/the-sex-gender-and-covid-19-project/the-data-tracker/ (accessed October 9, 2020).
48. Vardavas CI, Nikitara K. COVID-19 and smoking: a systematic review of the evidence. *Tob Induc Dis.* (2020) 18:20. doi: 10.18332/tid/119324
49. *Screening Starts at Dhaka, Ctg Airports | theindependentbd.com*. Available online at: http://www.theindependentbd.com/post/233343 (accessed October 8, 2020).
50. *Government Sends Plane Today to Fly Back Citizens*. Available online at: https://www.newagebd.net/article/98179/government-sends-plane-today-to-fly-back-citizens (accessed October 8, 2020).
51. *Expats Asked to Call IEDCR if in Difficulties*. Available online at: https://www.newagebd.net/article/100468/expats-asked-to-call-iedcr-if-in-difficulties (accessed October 8, 2020).
52. *Suspension-of-Schedule-International-Flights-To-From-bd*. Available online at: https://caab.portal.gov.bd/site/notices/e9172346-d6db-425c-854d-75007c5529fa/Suspension-of-Schedule-International-Flights-To-From-bd (accessed October 13, 2020).
53. Abul Kalam Azad P. *Government of the People's Republic of Bangladesh*. National Preparedness and Response Plan for COVID-19, Bangladesh Directorate General of Health Services Health Service Division Ministry of Health and Family Welfare.
54. *Bangladesh Sees First Lockdown in Madaripur*. Available online at: https://unb.com.bd/category/Bangladesh/bangladesh-sees-first-lockdown-in-madaripur/47542 (accessed October 8, 2020).
55. *Coronavirus Disease (COVID-2019) Bangladesh Situation Reports*. Available online at: https://www.who.int/bangladesh/emergencies/coronavirus-disease-(covid-19)-update/coronavirus-disease-(covid-2019)-bangladesh-situation-reports (accessed October 8, 2020).
56. *Biman Folds Its Wings | The Daily Star*. Available online at: https://www.thedailystar.net/frontpage/news/biman-folds-its-wings-1886875 (accessed October 8, 2020).
57. *School, College Shutdown Extended Till Oct 3 | Dhaka Tribune*. Available online at: https://www.dhakatribune.com/bangladesh/2020/08/27/holiday-for-all-educational-institutions-extended-till-sept-30 (accessed October 8, 2020).
58. *School, College Shutdown Extended Till Oct 31 | Dhaka Tribune*. Available online at: https://www.dhakatribune.com/bangladesh/education/2020/10/01/school-college-shutdown-extended-till-oct-31 (accessed October 8, 2020).
59. *Bangladesh Bank Announces Tk 30b Lending Scheme for Low-Income Groups - bdnews24.com*. Available online at: https://bdnews24.com/economy/2020/04/20/bangladesh-bank-announces-tk-30b-lending-scheme-for-low-income-groups (accessed October 8, 2020).
60. Lau H, Khosrawipour V, Kocbach P, Mikolajczyk A, Schubert J, Bania J, et al. The positive impact of lockdown in Wuhan on containing the COVID-19 outbreak in China. *J Travel Med.* (2020) 27:1–7. doi: 10.1093/jtm/taaa037
61. Coccia M. The relation between length of lockdown, numbers of infected people and deaths of Covid-19, and economic growth of countries: lessons learned to cope with future pandemics similar to Covid-19 and to constrain the deterioration of economic system. *Sci Total Environ*. (2021) 775:145801. doi: 10.1016/j.scitotenv.2021.145801
62. Renardy M, Eisenberg M, Kirschner D. Predicting the second wave of COVID-19 in Washtenaw County, MI. *J Theor Biol.* (2020) 507:110461. doi: 10.1016/j.jtbi.2020.110461
63. Arifuzzaman M, Siam ZS, Rashid MH, Islam MS. No lockdown policy for COVID-19 epidemic in Bangladesh: good, bad or ugly? *Int J Mod Phys C.* (2021) 32:1–7. doi: 10.1142/S0129183121500625
64. Shammi M, Bodrud-Doza M, Towfiqul Islam ARM, Rahman MM. COVID-19 pandemic, socioeconomic crisis and human stress in resource-limited settings: a case from Bangladesh. *Heliyon*. (2020) 6:e04063. doi: 10.1016/j.heliyon.2020.e04063
65. Mamun MA, Sakib N, Gozal D, Bhuiyan AI, Hossain S, Bodrud-Doza M, et al. The COVID-19 pandemic and serious psychological consequences in Bangladesh: a population-based nationwide study. *J Affect Disord.* (2021) 279:462–72. doi: 10.1016/j.jad.2020.10.036
66. Mistry SK, Ali ARMM, Akther F, Yadav UN, Harris MF. Exploring fear of COVID-19 and its correlates among older adults in Bangladesh. *Global Health.* (2021) 17:1–9. doi: 10.1186/s12992-021-00698-0
67. World Health Organization. *The Latest on the Covid-19 Global Situation & Long-Term Sequelae*. Update on Clinical long-term effects of COVID-19 (2021). Available online at: moz-extension:https://5b39ac29-3f54-4bd9-9314-7cb3d-d2c1f34/enhanced-reader.html?openApp&pdf=https%3A%2F%2F%2Fdocs%2Fdefault-source%2Fcoronaviruse%2Frisk-comms-updates%2Fupdate54_clinical_long_term_effects.pdf%3Fsfvrsn%3D3e63eee5_8 (accessed October 18, 2020).
68. *45% of Dhaka Dwellers Exposed to Covid-19, IEDCR Survey Says*. Available online at: https://www.thedailystar.net/45-percent-dhaka-dwellers-exposed-covid-19-iedcr-survey-says-1976777 (accessed June 26, 2021).
69. *IEDCR Survey in Dhaka: 45pc Carrying Coronavirus Antibody | The Daily Star*. Available online at: https://www.thedailystar.net/frontpage/news/iedcr-survey-dhaka-45pc-carrying-coronavirus-anti-body-1976929 (accessed June 26, 2021).
70. *Nearly 20 Lakh Dhaka Residents Could Be Covid-19 Positive, 78% Asymptomatic: Study | The Daily Star*. Available online at: https://www.thedailystar.net/coronavirus-deadly-new-threat/news/nearly-20-lakh-dhaka-residents-could-be-covid-19-positive-78-asymptomatic-study-1942953 (accessed June 26, 2021).
71. *Two in 3 Slum Dwellers Have Had Covid-19 | The Daily Star*. Available online at: https://www.thedailystar.net/backpage/news/two-3-slum-dwellers-have-had-covid-19-2116181 (accessed June 26, 2021).
72. Biswas RK, Afiaz A, Huq S. Underreporting COVID-19: the curious case of lower-income countries. *Epidemiol Infect*. (2020) 148:E207. doi: 10.1017/S0950268820002095

73. Mahmud AS, Chowdhury S, Sojib KH, Chowdhury A, Quader MT, Paul S, et al. Participatory syndromic surveillance as a tool for tracking COVID-19 in Bangladesh. *Epidemics.* (2021) 35:100462. doi: 10.1016/j.epidem.2021.100462
74. Lau H, Khosrawipour T, Kocbach P, Ichii H, Bania J, Khosrawipour V. Evaluating the massive underreporting and undertesting of COVID-19 cases in multiple global epicenters. *Pulmonology*. (2021) 27:110–5. doi: 10.1016/j.pulmoe.2020.05.015
75. Williams BGA, Díez SMU, Figueras J, Lessof S. Translating evidence into policy during the COVID-19 pandemic: bridging science and policy (and politics). *Eurohealth*. (2020) 26:29–33.
76. Henri H, Kluge P, Nitzan D, Azzopardi-muscat N. COVID-19: reflecting on experience and anticipating the next steps. A perspective from the WHO Regional Office for Europe. *Eurohealth*. (2020) 26:13–5.
77. Doyle A, Hynes W, Purcell SM. Building resilient, smart communities in a post-COVID Era: Insights from ireland. *Int J E-Planning Res.* (2021) 10:18–26. doi: 10.4018/IJEPR.20210401.oa2
78. Sagan A, Thomas S, Mckee M, Karanikolos M, Azzopardi-Muscat N, de la Mata I, et al. COVID-19 and health systems resilience: lessons going forwards. *Eurohealth*. (2020) 26:20–4.
79. Jewell NP, Lewnard JA, Jewell BL. Predictive mathematical models of the COVID-19 pandemic: underlying principles and value of projections. *JAMA*. (2020) 323:1893–4. doi: 10.1001/jama.2020.6585
80. Adam D. Special report: The simulations driving the world's response to COVID-19. *Nature*. (2020) 580:316–8. doi: 10.1038/d41586-020-01003-6
81. Ahmed F, Islam MA, Kumar M, Hossain M, Bhattacharya P, Islam MT, et al. First detection of SARS-CoV-2 genetic material in the vicinity of COVID-19 isolation Centre in Bangladesh: Variation along the sewer network. *Sci Total Environ.* (2021) 776:145724. doi: 10.1016/j.scitotenv.2021.145724
82. Schaffer Deroo S, Pudalov NJ, Fu LY. Planning for a COVID-19 vaccination program. *J Am Med Assoc.* (2020) 323:2458–9. doi: 10.1001/jama.2020.8711
83. Velavan TP, Meyer CG. The COVID-19 epidemic. *Trop Med Int Health*. (2020) 25:278–80. doi: 10.1111/tmi.13383
84. Saha S, Tanmoy AM, Hooda Y, Tanni AA, Goswami S, Al Sium SM, et al. COVID-19 rise in Bangladesh correlates with increasing detection of B.1.351 variant. *BMJ Glob Heal.* (2021) 6:1–3. doi: 10.1136/bmjgh-2021-006012
85. Logan J, Nederhoff D, Koch B, Griffith B, Wolfson J, Awan FA, et al. 'What have you HEARD about the HERD?' Does education about local influenza vaccination coverage and herd immunity affect willingness to vaccinate? *Vaccine*. (2018) 36:4118–25. doi: 10.1016/j.vaccine.2018.05.037
86. *Bangladesh's Vaccination Plan Unveiled | Dhaka Tribune*. Available online at: https://www.dhakatribune.com/health/coronavirus/2021/01/24/bangladesh-s-vaccination-plan-unveiled (accessed July 13, 2021).
87. *Covid-19 Vaccine Registration Site Now Open | Dhaka Tribune*. Available online at: https://www.dhakatribune.com/bangladesh/2021/01/27/covid-19-vaccine-registration-app-site-now-open (accessed July 13, 2021).
88. *COVID-19: Govt Brings Changes in Recovery Criteria | Prothom Alo*. Available online at: https://en.prothomalo.com/bangladesh/covid-19-changes-in-recovery-criteria (accessed July 8, 2021).

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BRIEF RESEARCH REPORT
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Knowledge and Self-Protective Practices Against COVID-19 Among Healthcare Workers in Vietnam

Anh Ngoc Nguyen[1†], Xuan Thi Thanh Le[1†], Nhung Thi Kim Ta[1], Danny Wong[2], Nguyen Thao Thi Nguyen[3], Huong Thi Le[1], Thao Thanh Nguyen[1], Quan Thi Pham[1], Quynh Thi Nguyen[1], Quan Van Duong[1], Anh Mai Luong[4], David Koh[5,6], Men Thi Hoang[7,8], Hai Quang Pham[7,8], Thuc Minh Thi Vu[9], Giang Thu Vu[10], Carl A. Latkin[11], Cyrus S. H. Ho[12,13] and Roger C. M. Ho[12,14]*

[1] School of Preventive Medicine and Public Health, Hanoi Medical University, Hanoi, Vietnam, [2] School of Nursing and Health Professions, University of San Francisco, San Francisco, CA, United States, [3] Duke School of Medicine, Duke University, Durham, NC, United States, [4] Vietnam Health Environment Management Agency, Ministry of Health, Hanoi, Vietnam, [5] Pengiran Anak Puteri Rashidah Sa'adatul Bolkiah (PAPRSB), Institute of Health Science, Universiti Brunei Darussalam, Gadong, Brunei, [6] SSH School of Public Health, National University of Singapore, Singapore, Singapore, [7] Institute for Global Health Innovations, Duy Tan University, Da Nang, Vietnam, [8] Faculty of Medicine, Duy Tan University, Da Nang, Vietnam, [9] Institute of Health Economics and Technology, Hanoi, Vietnam, [10] Center of Excellence in Evidence-Based Medicine, Nguyen Tat Thanh University, Ho Chi Minh City, Vietnam, [11] Bloomberg School of Public Health, Johns Hopkins University, Baltimore, MD, United States, [12] Department of Psychological Medicine, Yong Loo Lin School of Medicine, National University of Singapore, Singapore, Singapore, [13] Department of Psychological Medicine, National University Health System, Singapore, Singapore, [14] Institute for Health Innovation and Technology (iHealthtech), National University of Singapore, Singapore, Singapore

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Jongnam Hwang, Wonkwang University, South Korea

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Zia Ul Mustafa, Independent Researcher, Sahiwal, Pakistan
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***Correspondence:**
Hai Quang Pham
phamquanghai@duyttan.edu.vn

[†] These authors have contributed equally to this work

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Background: In middle-income countries such as Vietnam, where healthcare resources are already constrained, protecting healthcare workers (HCWs) is essential for ensuring the sustainability of COVID-19 response in Vietnam. This study was conducted to assess the knowledge and practices regarding the prevention of the COVID-19 among the HCWs in Vietnam to identify the ways of disseminating information to maximize the safety of these essential workers.

Methods: An online cross-sectional study, using respondent-driven sampling, was conducted in Vietnam with 742 participants within 2 weeks. The validity of the questionnaire was examined by exploratory factor analysis. Descriptive statistics were used to identify the level of knowledge and practices among the HCWs to prevent the COVID-19. Inferential statistics and regression modeling were used to identify the associated factors with results.

Results: Vietnamese HCWs had a high level of knowledge with more than 75% of the participants demonstrating awareness of all the modes of transmission aside from air. The mean knowledge score was 3.7 ± 0.8 (range 1–5). Nearly all the participants relied on the Ministry of Health (98.3%) and the internet (95.5%) for information regarding the COVID-19. The participants endorsed a moderately high level of self-protective practices with mean scores of 4.2 and 3.6 (band score 1–5) for the precautionary and psychological measures, respectively. Nurses were more likely to practice the precautionary measures than doctors and the HCWs at the central level were more likely to practice the psychological measures than those at the district level.

Conclusion: Future education initiatives should consolidate the latest literature in an accessible format, focusing initially on the gaps of knowledge regarding aerosol transmission. These initiatives should primarily focus on the doctors, especially those in emergency and intensive care departments.

Keywords: COVID-19, knowledge, practice, national lockdown, Vietnam

INTRODUCTION

In December 2019, China first reported the cases of pneumonia caused by SARS-CoV-2, the beginning of the global coronavirus disease 2019 (COVID-19) pandemic (1, 2). Since the initial outbreak, the healthcare workers (HCWs) have assumed an essential role in defending the health of the population and are at heightened risk of contracting infection (3). Italy, an early epicenter of the global COVID-19 pandemic, lost 151 doctors and more than 40 nurses to the COVID-19 by the end of April 2020 (4). In Northern Italy, the infection rate of the HCWs was documented to be about 20% (5). The US, a later epicenter, was found to have 62,344 confirmed COVID-19 cases and 291 deaths among the HCWs by late May 2020 (6).

In contrast to Italy and the US, the effects of the COVID-19 pandemic in Vietnam have been minimized with proactive interventions including early detection, timely isolation, and strict adherence to social distancing (5, 7–9). As a part of the prevention strategy in Vietnam, the Vietnamese government also implemented a partial 15-day national lockdown, closing restaurants and public spaces, stopping public transportation in high-risk areas, and restricting travel (10). As a result, on September 23, 2020, there have been only a total of 1,069 reported COVID-19 cases and 35 deaths in the country, a success story in terms of pandemic containment (11). In July 2020, only four Vietnamese HCWs have become infected (12). However, as of 12:56 GMT, August 28, 2021 (more than 1 year after the time of the study), a total of 422,469 reported COVID-19 cases and 10,405 deaths in Vietnam (13). Therefore, efforts to prevent HCW infection are especially crucial in Vietnam given preexisting constraints on the healthcare resources.

In addition to public health interventions, personal hygiene practices such as handwashing and adherence to personal protective equipment (PPE) are essential in efforts to prevent transmission. Previous studies have described the shortages of PPE globally (14–16). Vietnam is no different and many health workers have had to use non-medical grade face masks. In view of this, new recommendations have been released to guide mask allocation and usage (10, 17). However, HCW safety requires not only access to PPE but also sufficient knowledge and practices to prevent the COVID-19 transmission. Currently, studies on the latter among the HCWs in Vietnam are lacking.

Previous research on the knowledge and practices of HCWs in China found that 89% of the HCWs had sufficient knowledge and 89.7% followed correct practices for disease prevention (18). A similar study in Italy found overall adequate knowledge of the COVID-19 control measures among the HCWs (19). In Vietnam, one study found that the HCWs had a good understanding of the COVID-19 with a mean knowledge score of 8.17 (range 4–10). These data were collected from a single hospital in Ho Chi Minh City, Vietnam (20). Utilizing an online questionnaire to reach more participants, this study aims to characterize knowledge and practices of COVID-19 prevention among the HCWs across Vietnam.

By examining the sources of information of the HCWs, this study aims to identify ways to disseminate information to the HCWs. Moreover, due to the heterogeneity of the HCW population, this study also seeks to identify characteristics associated with gaps in knowledge and practices of COVID-19 prevention to guide the opportunities for further education.

METHODS

Study Setting and Respondents

A cross-sectional study was conducted on 2 weeks of early April 2020 during the partial national lockdown in Vietnam. At this point during the epidemic in Vietnam, more than 60% of the COVID-19 cases were brought from foreign countries including Hubei, Wuhan, and China, the initial epicenter of the COVID-19 pandemic. The eligibility criteria for the participants were the following: (1) occupation as an HCW, (2) agreement to participate through an online informed consent, and (3) ability to access the web-based questionnaire.

Sample and Sampling

Respondent-driven sampling was used to recruit the respondents. At the beginning of the recruitment process, a core group at the Hanoi Medical University was created. Members of this group were chosen based on the high likelihood of knowing HCWs at various hospitals throughout Vietnam. They were also selected to reflect a diverse range of characteristics including gender, age, and occupation. The core group sent the questionnaire link to their close contacts *via* platforms such as Facebook or Zalo. Respondents were able to access the questionnaire on computers, tablets, and smartphones, and they were also asked to invite the other Vietnamese HCWs to participate. A total of 742 HCWs participated in this study, which consisted of staff at the hospitals and the medical universities throughout all the 63 provinces.

Instruments and Measures

An online questionnaire was created by using the SurveyMonkey platform, which collected the data on the demographics and occupation of the participants along with knowledge and practices of the COVID-19 prevention. The questionnaire in Vietnamese was developed by the public health experts of

TABLE 1 | Participant demographics.

Characteristics	Geographical hospital divisions								*p*-value
	Central level		Provincial level		Others		Total		
	n	%	*n*	%	*n*	%	*n*	%	
Total	167	31.6	159	30.1	203	38.4	529	100.0	
Region									
Northern	151	90.4	85	53.5	144	70.9	380	71.8	< 0.01
Central	11	6.6	63	39.6	38	18.7	112	21.2	
South	5	3.0	11	6.9	21	30.3	37	7.0	
Gender									
Male	63	37.7	56	35.2	72	35.5	191	36.1	0.87
Female	104	62.3	103	64.8	131	64.2	338	62.9	
Marital status									
Single/Separated/Widowed	32	19.2	37	23.3	42	20.7	111	21.0	0.66
Married	135	80.8	122	76.7	161	79.3	418	79.0	
Living with									
Family/friends	154	92.2	147	92.5	189	93.1	490	92.6	0.94
Alone	13	7.8	12	7.6	14	6.9	39	7.4	
Education									
University and lower	71	42.5	102	64.2	141	69.5	314	59.4	< 0.01
>University	96	57.5	57	35.9	62	30.5	215	40.6	
Occupation									
Doctor	104	62.3	76	47.8	113	55.7	293	55.4	< 0.01
Nurse	30	18.0	54	34.0	40	19.7	124	23.4	
Others	33	19.8	29	18.2	50	24.6	112	21.2	
Department									
Emergency-intensive care	6	3.6	20	12.6	17	8.4	43	8.1	< 0.01
Internal medicine	28	16.8	20	12.6	20	9.9	68	12.9	
Surgery-obstetrics-pediatrics	24	14.4	22	13.8	20	9.9	66	12.5	
Radiology-scientific laboratory-clinic	34	20.4	16	10.1	39	19.2	89	16.8	
Administrative offices	14	8.4	32	20.1	28	13.8	74	14.0	
Infectious disease-infection control	10	6.0	6	3.8	9	4.4	25	4.7	
Preventive medicine-public health-nutrition	29	17.4	5	3.1	33	16.3	67	12.7	
Others	22	13.2	38	23.9	37	18.2	97	18.3	
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***p*-value**
Age	35.8	9.1	34.7	8.3	36.4	9.0	35.7	8.9	0.17
Durationof career (years)	10.5	8.5	10.6	8.2	11.5	8.9	10.9	8.6	0.54

the Institute of Preventive Medicine and Public Health, Hanoi Medical University. It was based on the questionnaires regarding the perception of risk of the HCWs and the preventive measures for SARS in Singapore. Demographic characteristics consisted of information such as age, gender, marital status, religion, ethnic group, education level, and home environment. Occupational characteristics included job title and current work status.

Finally, to evaluate for the knowledge and practices of the COVID-19 prevention, the questionnaire asked participants to rate the statements on knowledge and self-protective actions to prevent the COVID-19 on a 5-point Likert scale in which 1 representing "strongly disagree" and 5 representing "strongly agree."

Data Analysis

The collected data were analyzed by using STATA 15.0 (StataCorp LP, College Station, Texas, United States). Characteristic data including mean, SD, frequency, and percentage were examined by using descriptive statistics. Inferential statistics were used to compare the HCWs at the central hospitals, provincial hospitals, and other hospitals. The Fisher's exact or chi-squared tests were used for the qualitative variables and ANOVA or Kruskal–Wallis test were used for the quantitative variables. A multivariable linear regression model was used to identify the factors associated with knowledge and practices of COVID-19 prevention. The stepwise forward selection was utilized to obtain reduced models with a log-likelihood ratio test at a p-value of 0.2. Statistical significance was set at a $p < 0.05$.

TABLE 2 | Knowledge, sources of information, preferences for training platform, and practice on the transmission and self-prevention against the coronavirus disease 2019 (COVID-19).

Characteristics	Level of hospital								*p*-value
	Central level		Provincial level		Others		Total		
	n	%	*n*	%	*n*	%	*n*	%	
Knowledge of transmission									
Air	64	52.5	65	60.8	90	57.7	219	26.9	0.44
Close contact with COVID-19 patients	88	72.1	77	72.0	1,126	80.8	291	75.6	0.15
Colleagues with contact with COVID-19 patients	91	74.6	84	78.5	131	84.0	306	79.5	0.15
Surface with nasal/throat secretions of COVID-19 patients	93	76.2	83	77.6	115	73.7	291	75.6	0.76
Source of information about COVID-19									
WHO	118	70.7	93	58.5	115	56.7	326	61.6	0.01
Ministry of Health	164	98.2	157	98.7	199	98.0	520	98.3	0.92
CDC	103	61.7	82	51.6	115	56.7	300	56.7	0.18
University/ Hospital	119	71.3	90	56.9	101	49.8	310	58.6	< 0.01
Colleague	109	65.3	99	62.3	121	59.6	329	62.2	0.54
Friends	70	41.9	65	40.9	77	37.9	212	40.1	0.72
Others	19	11.4	14	8.8	28	13.8	61	11.5	0.34
Mass media channel for information seeking									
Internet	162	97.0	151	95.0	192	94.6	505	95.5	0.50
Television	130	77.8	135	84.9	177	87.2	442	83.6	0.05
Radio	55	32.9	61	38.4	90	44.3	206	38.9	0.08
Newspaper	95	56.9	96	60.4	124	61.1	315	59.6	0.69
Other	14	8.4	9	5.7	14	6.9	37	7.0	0.63
Information about COVID-19 that you want to know more									
Nothing	31	18.6	19	12.0	37	18.2	87	16.5	0.19
Epidemiology	73	43.7	65	40.9	86	42.4	224	42.3	0.88
Infection control and prevention	90	53.9	89	56.0	102	50.3	281	53.1	0.54
Disease management	80	47.9	74	46.5	83	40.9	237	44.8	0.35
PPE use	61	36.5	71	44.7	81	39.9	213	40.3	0.32
Forms of training desired									
Direct training	27	16.2	39	24.5	39	19.2	105	19.9	0.16
Online lecture	83	49.7	61	38.4	81	39.9	225	42.5	0.07
Online seminar/webinars	49	29.3	38	23.9	47	23.2	134	25.3	0.35
Phone application	66	39.5	67	42.1	63	31.0	196	37.1	0.07
Text documents	53	31.7	65	40.9	54	26.6	172	32.5	0.02
	Mean	**SD**	**Mean**	**SD**	**Mean**	**SD**	**Mean**	**SD**	***p*-value**
Adequate knowledge of transmission (band score 1–5)	3.7	0.8	3.7	0.7	3.7	0.9	3.7	0.8	0.63
Self-protective actions									
Seek information about COVID-19	4.5	0.6	4.4	0.7	4.4	0.9	4.4	0.7	0.48
Comply with recommendations and preventive measures of the Ministry of Health	4.6	0.6	4.5	0.6	4.4	0.8	4.5	0.7	0.46
Avoid crowded places	4.5	0.6	4.5	0.6	4.3	0.9	4.4	0.7	0.17
Avoid contact with colleagues at risk of COVID-19 exposure	3.7	0.9	3.6	0.9	3.4	1.0	3.6	1.0	0.02
Nutritional supplements, vitamins	4.0	0.8	4.0	0.8	4.0	0.9	4.0	0.8	0.58
Exercise regularly	4.0	0.8	4.0	0.8	3.9	0.9	4.0	0.8	0.80
Try not to think about the risks of COVID-19	3.3	1.0	3.2	1.0	3.3	1.0	3.3	1.0	0.41
Stay positive and convince yourself that you will not be infected with COVID-19	3.9	0.8	3.8	0.9	3.8	0.8	3.8	0.8	0.73
Accept the risk of COVID-19 infection	3.8	0.7	3.7	0.8	3.7	0.8	3.7	0.7	0.30

Ethical Consideration

This project was ethically approved by the Review Committee at the Institute of Preventive Medicine and Public Health, Hanoi Medical University on March 28, 2020. The research purpose and informed consent were provided on the web-based survey before participation. Participation was anonymous and

TABLE 3 | Measures taken to self-protect from COVID-19.

I have prevented COVID-19 when I	Strongly agree		Precautionary measures	Measures toimprovepsychological well-being
	n	%		
Comply with Ministry of Health recommendations and preventive measures	298	56.3	0.92	
Avoid crowded places	273	51.6	0.90	
Seek information about COVID-19	267	50.5	0.88	
Nutritional supplements, vitamins	155	29.3	0.65	
Exercise regularly	143	27.0	0.60	
Avoid contact with colleagues at risk of exposure to COVID-19	83	15.7	0.42	
Stay positive and convince yourself that you will not be infected with COVID-19	95	18.0		0.78
Accept the risk of COVID-19 infection	50	9.5		0.54
Try not to think about the risks of COVID-19	46	8.7		0.77
Cronbach's alpha			0.83	0.55
Mean			4.2	3.6
SD			0.6	0.6

voluntary and respondents could withdraw from this study at any point.

RESULTS

Table 1 shows the demographic characteristics of the participants in this study. Most of the respondents (62.9%) were females and they worked in Northern Vietnam (71.8%). More than half of the respondents were doctors (55.4%) and they were educated at the lower university level (59.4%). Regarding department, 16.8% of the participants worked in radiology, scientific laboratories, or clinic; 14.0% of the participants worked in the administrative offices; and only 4.7% of the participants worked in infectious disease and infection control.

Table 2 summarizes the knowledge, source of information, and practices regarding COVID-19 prevention among the participants. The majority of the participants knew that close contact with colleagues who have cared for the patients with the COVID-19 (79.5%), directly caring for the patients with the COVID-19 (75.6%), or touching surface containing nasal or salivary secretions of the patients with the COVID-19 (75.6%) could increase the risk of developing the COVID-19. Less than half of the participants (41.4%) knew that the SARS-CoV-2 virus could be transmitted by air. On a scale of 1–5, the average knowledge score of the respondents was 3.7 (SD = 0.8). The internet (95.5%) and television (83.6%) were the most popular media channel for seeking information. Moreover, the Ministry of Health was the most widely used source of information with 98.3% of all the participants obtaining information. Regarding the practices, the average score was relatively high ranging from 3.3 to 4.5. Practices with the highest rates of engagement were seeking information about the COVID-19, complying with the Ministry of Health preventive recommendation, and avoiding crowded places (average scores 4.4, 4.5, and 4.4, respectively).

The construct validity of self-protection from the COVID-19 is displayed in **Table 3**. Self-protective actions were subdivided into two categories: precautionary measures to prevent disease transmission and psychological measures to promote mental well-being. **Table 4** demonstrates the values of Cronbach's alpha for those categories that were 0.83 and 0.55, respectively.

Table 4 represents the relationships between the demographic characteristics and source of information with the perceived knowledge and practices of the respondents against the COVID-19. Aside from those who worked in the preventive medicine, public health, and nutrition departments, we found that the HCWs in all the other departments were more likely to have adequate knowledge of SARS-CoV-2 virus transmission and the COVID-19 prevention than those in the emergency and intensive care unit.

Nurses were more likely to practice precautionary measures against the COVID-19 compared to doctors (Coef. = 0.18, 95% CI = 0.02–0.34). HCWs with an education level higher than university (Coef. = 0.18, 95% CI = 0.05–0.30) and who had adequate knowledge of transmission (Coef. = 0.20, 95% CI = 0.13–0.27) were also more likely to engage in the precautionary measures than their counterparts.

In terms of psychological well-being, the HCWs at the district level health centers were less likely to engage in self-protective practices than working at the central hospitals (Coef. = 0.18, 95% CI = 0.31–0.04). Meanwhile, using the internet for information about the COVID-19 was correlated with greater implementation of the measures to improve psychological well-being (Coef. = 0.57, 95% CI = 0.22–0.92).

TABLE 4 | Associated factors of the knowledge and practices against the COVID-19.

Factors	Adequate knowledge ofSARS-CoV-2transmission		Self-protection from COVID-19			
			Precautionary measures		Measures to improve psychological well-being	
	Coef.	95% CI	Coef.	95% CI	Coef.	95% CI
Region (vs. Northern)						
Central					0.12	−0.04; 0.28
South	1.47**	1.08; 2.00				
Gender (vs. Male)						
Female			−0.12*	−0.24; 0.00		
Education (vs. University and lower)						
> University			0.18***	0.05; 0.30		
Occupation (vs. Doctor)						
Nurse			0.18**	0.02; 0.34	0.25***	0.10; 0.40
Others	0.81*	0.66; 1.00				
Level of hospital (vs. Central level)						
District health center					−0.18**	−0.31; −0.04
Others			−0.12	−0.29; 0.05		
Department (vs. Emergency-Intensive care)						
Surgery-obstetrics-pediatrics	0.74**	0.57; 0.97	−0.14	−0.33; 0.04		
Administrative offices	0.75**	0.58; 0.96				
Infectious disease-infection control	0.76**	0.58; 0.98				
Preventive medicine-public health- nutrition	0.78	0.54; 1.12	−0.26*	−0.52; 0.00		
Others	0.73***	0.58; 0.92				
Adequate knowledge of transmission			0.20***	0.13; 0.27	0.07*	−0.00; 0.15
Source of information about COVID-19						
CDC					0.09	−0.03; 0.22
University/Hospital			0.1	−0.02; 0.22		
Mass media channel for information seeking (vs. television)						
Internet	1.19	0.92; 1.55			0.57***	0.22; 0.92
Radio			0.13**	0.01; 0.25		
Newspaper	0.84**	0.70; 1.00			−0.13**	−0.26; −0.00
Other	1.36*	0.99; 1.86				
Aspect of COVID-19 that respondents wanted to know more about						
Epidemiology COVID-19			0.11*	−0.01; 0.22	0.35***	0.22; 0.48
Case management	1.18*	0.99; 1.41				
Using PPE					−0.21***	−0.34;−0.08

$^{***}p < 0.01$; $^{**}p < 0.05$; $^{*}p < 0.1$.

DISCUSSION

To the best of our knowledge, this study is among the first to examine both the knowledge and self-protective practices to prevent the COVID-19 among the HCWs in Vietnam. Overall, the results showed that Vietnamese HCWs have a high level of knowledge with more than 75% of the participants demonstrating awareness of all the modes of transmission aside from air. The mean knowledge score was 3.7. The HCWs in the emergency and intensive care departments had lower knowledge scores than those in nearly all other departments. Further, participants endorsed a high level of self-protective practices with mean scores of 4.2 and 3.6 for the precautionary and psychological measures, respectively. Nurses were more likely to practice the precautionary measures than doctors and the HCWs at the central level were more likely to practice the psychological measures than those at the district level.

The knowledge levels in this study are lower than those found among the HCWs in Pakistan (21) and higher than nurses in Iran (22). In comparison to a prior study conducted at a hospital in Ho Chi Minh City, Vietnam, the knowledge score in this study was slightly lower. However, with respect to transmission, a greater proportion of the participants in this study was aware

of disease spread through close contact (20). Overall, the level of knowledge regarding transmission by contact with infected people and surfaces echoes findings from prior studies (23, 24). A knowledge gap on aerosol transmission was also found. It is likely due to the limited data on the aerosol transmission during the pandemic when this study was conducted. Since then, research has emerged to suggest the possibility of short-range aerosol transmission (25, 26). As such, future initiatives among the HCWs in Vietnam should focus on education regarding the COVID-19 transmission by air and its implications on self-protective clinical practices.

Compared to hospital staff in the other departments, those in emergency and intensive care units had lower knowledge about the COVID-19 transmission. Precluding them from seeking up-to-date literature about the COVID-19 may be due to the longer shifts and overall higher stress from caring for the severe patients (27–31). Given the time constraints of the HCWs, interventions should focus on consolidating information efficiently to ensure that the healthcare providers have access to updated data in the midst of high clinical demands, specifically those in emergency and intensive care units. The most popular sources of information reported by the participants were the Ministry of Health and the Internet that are reflective of findings from the previous studies (23, 32). Therefore, those mediums should be the primary focus channels of future educational campaigns. Moreover, our data emphasize the importance of keeping the Ministry of Health website routinely updated to ensure that healthcare providers have access to the latest data to guide patient care.

Regarding self-protective practices, our study found that the participants had higher levels of engagement with the precautionary measures compared with the psychological measures. This finding may represent the prioritization of physical health over mental well-being during the initial phases of the COVID-19 outbreak. The higher levels of the precautionary practices are likely attributable to the strict control measures by the Vietnamese government with significant fines for violations (33). However, as the course of the pandemic progresses and its psychological effect becomes more apparent (34), our data suggests the need for the healthcare systems to facilitate the targeted efforts to promote the mental and emotional well-being of the HCWs.

As well-documented in literature with the COVID-19 (35) and the other disease outbreaks (36, 37), knowledge scores were positively associated with practice scores. This finding emphasizes the pivotal role of education in promoting compliance with public health interventions. Nurses practiced precautionary measures at greater rates than doctors. It is likely due to the greater levels of interaction with the COVID-19 patients on a daily basis. Future interventions should continue to focus on the doctors to ensure that they are leading as team leaders. With respect to psychological measures, the HCWs at the central level hospitals had higher practice scores than those at the district level. This likely relates to greater levels of staff support available at the central level. Future interventions should ensure equitable distribution of the resources for health workers at all levels of the health system.

Our research had several limitations. A cross-sectional study had conducted at the beginning of the COVID-19 pandemic in Vietnam. Further research will be needed to identify trends in the knowledge and practices of HCWs in later phases of the COVID-19 pandemic. Second, despite a high number and diversity of the participants, our respondents were not randomly selected and are not representative of the Vietnamese HCWs population. Lastly, though the questionnaire is the first national survey to provide a glimpse into the knowledge and practices of the HCWs in Vietnam, the number of items assessed for the knowledge and practices was limited. Further, the internal validity of the psychological measures was low. Future studies will be needed to better characterize these variables, particularly the psychological practices among the HCWs to guide future interventions.

CONCLUSION

This study found that the Vietnamese HCWs had a high level of knowledge and practices to prevent the COVID-19, though there was some room for improvement. Future education initiatives should focus initially on the COVID-19 virus aerosols that fill an important gap of knowledge. The Ministry of Health website should be considered for rapid dissemination of information. Doctors, especially those in emergency and the intensive care departments, should be a primary focus of these initiatives. At the same time, greater efforts will be needed to promote HCW engagement with the psychological self-protective practices, particularly among those working at the district levels.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by this project was ethically approved by the Review Committee at Institute for Preventive Medicine and Public Health, Hanoi Medical University on March 28, 2020. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

AN, XL, NT, DW, HL, TN, QP, QN, QD, AL, DK, MH, HP, TV, GV, CL, CH, and RH contributed to conceptualization, writing, reviewing, and editing. NT, TN, QP, QN, QD, and MH contributed to data curation. XL, AN, NT, and HP contributed to formal analysis. XL, AN, NT, HL, AL, DK, and RH contributed to the investigation. XL, AN, NT, HP,

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REFERENCES

1. WHO. *Coronavirus Disease* 2019 (*COVID-19).* (2020). Available online at: https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200219-sitrep-30-covid-19.pdf?sfvrsn=3346b04f_2 (accessed April 20, 2020).
2. Singhal T. A review of coronavirus disease-2019 (COVID-19). *Indian J Pediatrics.* (2020) 87:281–6. doi: 10.1007/s12098-020-03263-6
3. Nguyen LH, Drew DA, Joshi AD, Guo C, Ma W, Mehta RS, et al. Risk of COVID-19 among front-line health-care workers and the general community: a prospective cohort study. *Lancet Public Health.* (2020) 5:e475–83. doi: 10.1101/2020.04.29.20084111
4. Nava S, Tonelli R, Enrico M. Clini, An Italian sacrifice to the COVID-19 epidemic. *Europ Respir J.* (2020) 55:2001445. doi: 10.1183/13993003.01445-2020
5. Remuzzi A, Remuzzi G. COVID-19 and Italy: what next? *Lancet.* (2020) 395:1225–8. doi: 10.1016/S0140-6736(20)30627-9
6. Vaidya A. *More Than 62,000 US Healthcare Workers Have COVID-19, CDC Says.* (2020). Available online at: https://www.beckershospitalreview.com/workforce/more-than-62-000-us-healthcare-workers-have-covid-19-cdc-says.html (accessed September 23, 2020)
7. Vietnamese Government. *Directive No. 16 / CT-TTg on Urgent Measures to Prevent and Combat Against COVID-19 Epidemic.* Hanoi (2020).
8. Vietnamese Government. *Decision 447/QD-TTg on Announcing the Epidemic.* Hanoi (2020).
9. CDC. *Social Distancing for Tribal Communities with Local COVID-19 Transmission.* (2020). Available online at: https://www.cdc.gov/coronavirus/2019-ncov/community/tribal/social-distancing.html (accessed April 21, 2020).
10. Vietnamese Ministry of Health. *The Vietnamese Ministry of Health Shows How to Select and Use Masks in COVID-19 Epidemic.* (2020). Available online at: https://ncov.moh.gov.vn/web/guest/-/bo-y-te-chi-cach-lua-chon-su-dung-khau-trang-phong-dich-covid-19 (accessed April 23, 2020).
11. Huaxia. *Vietnam Records no New COVID-19 Cases, Total Stands at 1,063.* (2020). Available online at: http://www.xinhuanet.com/english/2020-09/15/c_139370684.htm (accessed September 23, 2020)
12. World Health Organization: Representative Office for Viet Nam. *Viet Nam COVID-19 Situation Report #1.* Hanoi: World Health Organization (2020).
13. Worldometer. *Coronavirus.* (2021). Available from at: https://www.worldometers.info/coronavirus/ (accessed August 28, 2021)
14. Ranney ML, Griffeth V, and Jha AK. Critical supply shortages — The Need for Ventilators and Personal Protective Equipment during the Covid-19 Pandemic. (2020) 382:e41. doi: 10.1056/NEJMp2006141
15. WHO. *WHO Director-General's Opening Remarks at the Media Briefing on COVID-19 - 27 March.* 2020 (2020). Available at: https://www.who.int/dg/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19--27-march-2020 (accessed April 23, 2020)
16. WHO. *WHO Director General's Remarks at the G20 Extraordinary Leaders' Summit on COVID-19 - 26 March.* 2020 (2020). Available online at: https://www.who.int/dg/speeches/detail/who-director-general-s-remarks-at-the-g20-extraordinary-leaders-summit-on-covid-19--26-march-2020 (accessed April 23, 2020)
17. CDC. *Interim Infection Prevention and Control Recommendations for Patients With Suspected or Confirmed Coronavirus Disease.* 2019. (*COVID-19) in Healthcare Settings.* (2020). Available online at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/infection-control-recommendations.html (accessed April 23, 2020)
18. Zhang M, Zhou M, Tang F, Wang Y, Nie H, Zhang L, et al. Knowledge, attitude and practice regarding COVID-19 among health care workers in Henan, China. *J Hosp Infect.* (2020) 105:183–7. doi: 10.1016/j.jhin.2020.04.012
19. Moro M, Vigezzi GP, Capraro M, Biancardi A, Nizzero P, Signorelli C, et al. 2019-novel coronavirus survey: knowledge and attitudes of hospital staff of a large Italian teaching hospital. *Acta Bio-med.* (2020) 91:29–34. doi: 10.23750/abm.v91i3-S.9419
20. Giao H, Thi Ngoc Han N, Van Khanh T, Kim Ngan V, Van Tam V, Le An P. Knowledge and attitude toward COVID-19 among healthcare workers at District 2 Hospital, Ho Chi Minh City. *Asian Pacific J Trop Med.* (2020) 13:260. doi: 10.4103/1995-7645.280396
21. Saqlain M, Munir MM, Rehman SU, Gulzar A, Naz S, Ahmed Z, et al. Knowledge, attitude, practice and perceived barriers among healthcare workers regarding COVID-19: a cross-sectional survey from Pakistan. *J Hosp Infect.* (2020) 105:419–23. doi: 10.1016/j.jhin.2020.05.007
22. Nemati M, Ebrahimi B, Nemati F. Assessment of Iranian nurses' knowledge and anxiety toward COVID-19 during the current outbreak in Iran. *Arch Clin Infect Dis.* (2020) 15:e102848. doi: 10.5812/archcid.102848
23. Karasneh R, Al-Azzam S, Muflih S, Soudah O, Hawamdeh S, Khader Y. Media's effect on shaping knowledge, awareness risk perceptions and communication practices of pandemic COVID-19 among pharmacists. *Res Soc Admin Pharm.* (2020) 17:1897–902. doi: 10.1016/j.sapharm.2020.04.027
24. Asraf H, Garima T, Singh BM, Ram R, Tripti RP. Knowledge, attitudes, and practices towards COVID-19 among Nepalese Residents: a quick online cross-sectional survey. *Asian J Med Sci.* (2020) 11:6–11. doi: 10.3126/ajms.v11i3.28485
25. CDC. *COVID-19 & IPC Overview.* (2020). Available from online at: https://www.cdc.gov/coronavirus/2019-ncov/hcp/non-us-settings/overview/index.html#r3 (accessed September 28, 2020)
26. Ma J, Qi X, Chen H, Li X, Zhang Z, Wang H, et al. COVID-19 patients in earlier stages exhaled millions of SARS-CoV-2 per hour. *Clin Infect Dis.* (2020) 72:e652–4. doi: 10.1093/cid/ciaa1283
27. Weigl M, Händl T, Wehler M, Schneider A. Time-allocation study of nurse and physician activities in the emergency department. *Med Klin Intensivmed Notfmed.* (2020) 116:229–37. doi: 10.1007/s00063-020-00657-4
28. Silvia PC, Jesús C, Javier H, Manuel VA. A multicenter study into burnout, perceived stress, job satisfaction, coping strategies, and general health among emergency department nursing staff. *J Clin Med.* (2020) 9:1007. doi: 10.3390/jcm9041007
29. Elder E, Amy NBJ, Marianne W, Julia C. The demoralisation of nurses and medical doctors working in the emergency department: a qualitative descriptive study. *Int Emerg Nurs.* (2020) 52:100841. doi: 10.1016/j.ienj.2020.100841
30. Durand AC, Bompard C, Sportiello J, Michelet P, Gentile S. Stress and burnout among professionals working in the emergency department in a French university hospital: Prevalence and associated factors. *Work.* (2019) 63:57–67. doi: 10.3233/WOR-192908
31. Bardhan R, Heaton K, Davis M, Chen P, Dickinson DA, Lungu CT. A cross sectional study evaluating psychosocial job stress and health risk in emergency department nurses. *Int J Environ Res Public Health.* (2019) 16:3243. doi: 10.3390/ijerph16183243
32. Chew NWS, Lee GKH, Tan BYQ, Jing M, Goh Y, Ngiam NJH, et al. A multinational, multicentre study on the psychological outcomes and associated physical symptoms amongst healthcare workers during COVID-19 outbreak. *Brain Behav Immun.* (2020) 8:559–65. doi: 10.1016/j.bbi.2020.04.049

33. *Tuan V, Vietnam PM. Gets Tough on Social Distancing Violations.* (2020). Available online at: https://e.vnexpress.net/news/news/vietnam-pm-gets-tough-on-social-distancing-violations-4082548.html (accessed September 28, 2020).
34. Neto MLR, Almeida HG, Esmeraldo JD, Nobre CB, Pinheiro WR, Oliveira CRT, et al. When health professionals look death in the eye: the mental health of professionals who deal daily with the 2019 coronavirus outbreak. *Psychiatry Res.* (2020) 288:112972. doi: 10.1016/j.psychres.2020.112972
35. Kamate SK, Sharma S, Thakar S, Srivastava D, Sengupta K, Hadi AJ, et al. Assessing Knowledge, Attitudes and Practices of dental practitioners regarding the COVID-19 pandemic: a multinational study. *Dental Med Prob.* (2020) 57:11–17. doi: 10.17219/dmp/119743
36. Holakouie-Naieni K, Ahmadvand A, Raza O, Assan A, Elduma AH, Jammeh A, et al. Assessing the knowledge, attitudes, and practices of students regarding ebola virus disease outbreak. *Iran J Public Health.* (2015) 44:1670–6. PMID: 26811818; PMCID: PMC4724740.
37. Zhong BL, Luo W, Li HM, Zhang QQ, Liu XG, Li WT, et al. Knowledge, attitudes, and practices towards COVID-19 among Chinese residents during the rapid rise period of the COVID-19 outbreak: a quick online cross-sectional survey. *Int J Biol Sci.* (2020) 16:1745–52. doi: 10.7150/ijbs.45221

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A Cross-Sectional Survey of Knowledge, Attitude, and Practices of University Students in Pakistan Regarding COVID-19

Sohail Raza[1], Nadia Mukhtar[1], Muhammad Nawaz[1], Muhammad Asad Ali[1], Muhammad Abu Bakr Shabbir[1], Muhammad Adnan Ashraf[1], Zeeshan Ali[2], Muhammad Rizwan Saleem[2], Rabia Latif[3] and Tahir Yaqub[1]*

[1] Institute of Microbiology, University of Veterinary and Animal Sciences, Lahore, Pakistan, [2] Information Technology Center, University of Veterinary and Animal Sciences, Lahore, Pakistan, [3] Department of Anatomy, University of Health Sciences Lahore, Lahore, Pakistan

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Ahmad Fauzi,
Universitas Muhammadiyah Malang, Indonesia

***Correspondence:**
Muhammad Nawaz
muhammad.nawaz@uvas.edu.pk

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The COVID-19 pandemic is striking the world with serious public health and socioeconomic complications. The pandemic has influenced all forms of daily life, including educational institutions. Therefore, this cross-sectional survey was conducted to understand knowledge, attitudes, and practices related to COVID-19 among the students of the University of Veterinary and Animal Sciences, Lahore. The data was collected using an online self-directed questionnaire. The survey form includes six items about sociodemographic characteristics, 14 knowledge-based questions, seven questions on attitude, and eight questions on practices. The sample number was calculated using the Raosoft sample size calculator. A total number of 3,854 students, including 1,823 men and 2,031 women, were engaged in this survey, having student representation from all the provinces in the country. The data were analyzed using a chi-square test. A total of 97% of the students knew that the etiological agent of COVID-19 is a virus and that it is a disease of the respiratory system (94%). Many students kept visiting their relatives during the lockdown (45%), and their relatives kept visiting them at home (59%). The responses from the students varied a lot on specific questions about the transmission of the virus. Women tended to have less information regarding precautionary travel measures ($p < 0.01$), but supplemental knowledge of prevention of disease transmission from positive patients ($p < 0.01$). Conclusively, the majority of the university students surveyed had imperative knowledge, a good attitude, and active practice in response to the COVID-19 outbreak. Moreover, the KAP scores have varied by demography, gender, and the number of family members. Therefore, continuous awareness of preventative behaviors should be disseminated regularly in emergencies.

Keywords: COVID-19 pandemic, KAP survey, health, education, Pakistan

INTRODUCTION

In December 2019, an outbreak of respiratory disease erupted in Wuhan market, P.R. China. The initial few cases had the history of working in the fish market in Wuhan, where wet animals including bats were being sold (1). The outbreak is believed to have started from the transmission of the virus from animals to humans. The disease was very contagious and human-to-human spread was very swift. The virus was preliminarily named as a novel coronavirus (n-CoV) which was renamed as severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (2). The disease spread to 18 countries within 2 months which prompted the World Health Organization (WHO) to declare it as Public Health of International Concern on January 30, 2020 (3). The number of cases persistently increased, which resulted in the WHO declaring it as a pandemic on March 11, 2020. As of April 17, 2021, the total number of people who have been infected with COVID-19 is 140,598,841 while 3,014,240 people have died of the disease. The cases in Pakistan increased rapidly as well with the first case reported on February 26, 2020 (4), while 750,158 cases have been reported and 16,094 people have lost their lives to COVID-19 as of April 17, 2021.

The infectious period of COVID-19 has not been completely elucidated at the time of this study, and the incubation period of SARS-CoV-2 varies from 5 to 14 days (5). The virus affects the lower respiratory tract leading to pneumonia although it can also affect the gastrointestinal tract, liver, kidney, and multiple organs (6). Scientists from multiple countries have collaborated under the Coalition for Epidemic Preparedness Innovations (CEPI) on the development of a vaccine. Many scientists have worked on the repurposing of already available drugs. Approval and availability of vaccines and drugs require time to ensure their safety before mass production and widespread use (7). Some antiviral drugs including hydroxychloroquine, favipiravir, lopinavir, and remdesivir are being tested in Phase III and Phase IV trials. Currently, the most effective way to prevent the spread of disease is to follow the Standard Operating Procedures and guidelines shared by the WHO and the Center for Disease Control (CDC).

At time of writing, Pakistan is tackling the fourth wave of COVID-19. The positivity rate of COVID-19 varies from 4 to 11 percent. The management strategies include awareness campaigns regarding the transmission and prevention of the disease. Before vaccine availability, the smart lockdown strategy of Pakistan has let the economy keep moving and kept the disease under control. Cities showing high positivity rates are brought under lockdown, and public gatherings are banned. The intermittent lockdown strategy is one of the success stories of Pakistan. After vaccine availability, the mass vaccination of people has played its role in controlling of the disease. A total of 25,493,964 people in Pakistan have at present been completely vaccinated. Nevertheless, much of the population does not believe in the existence of coronavirus, therefore, there is a continuous need to educate people both conventionally and non-conventionally.

In Pakistan, the National Institute of Health has also shared the guidelines and arranged training sessions to strengthen preventive measures, which emphasized frequent hand washing, mandatory face mask use, and maintaining social distancing. Government and non-government organizations and print, electronic, and social media have done massive awareness campaigns regarding prevention measures (8). Nevertheless, the cultural norms of Pakistan having a cordial community make it difficult to maintain social distancing over a longer period of time. As with the disease spreading fast, scientific data evolved rapidly on a daily basis. On another aspect, there is mixed information available the disease, further much of the incorrect information available through social media creates an "infodemic", which develops unnecessary fear among the community (9).

It is evident from previous pandemics that lack of knowledge and intention to practice SOPs mitigates the efforts to control the spread of disease (10). Several previous studies based on the KAP survey provide insight into COVID-19 information and practices of the students of universities, colleges, and general people in society. This helps policymakers to make efficient policy considering the results of the survey in order to control the spread of the disease (11–13). Amidst the infodemic, Universities are opening, although, the battle is still going on against COVID-19. Multiple studies have been done to know the response of the community to the COVID-19 disease, but few studies were planned for the students of universities. University students can reflect the view of the educated youth of diverse communities. A delicate balance between the Knowledge, Attitude, and Practices (KAP) of a community is required; therefore, there was the need for a survey that could reflect students' understanding of COVID-19 during December 2020. The perceived efficacy of KAP will help to underpin the thorough guidelines and SOPs for universities. This may help the government to devise effective SOPs and awareness campaigns.

MATERIALS AND METHODS

Study Designs and Participants

A cross-sectional study was conducted in December 2020 among the students of the University of Veterinary and Animal Sciences (UVAS), Lahore with approval. The collection of the data was according to the regulations of the Institutional Ethical committee based on the Helsinki declaration. Anonymity was ensured while the collection of information. The sampling technique for the study was non-probability convenience sampling. Data were obtained from the students of UVAS, Lahore. The campus is located in the heart of Lahore city, which is the capital of the Punjab province, Pakistan. The students of university have inclusiveness from all the provinces along with representation from foreign countries. The sample size was attained through the Raosoft sample size calculator. The total estimated size is 3,854 with a 95% confidence level, ±1% margin of error, and 50% response distribution.

The participants were categorized by gender, location, age, and degree program. The participants included 1,823 students who were men, and 2031 students who were women. A total of 2,871 students were from the cities while 983 students were from villages or rural areas. The majority of the students were studying

in undergraduate degree programs (2,853), followed by Masters (817), and PhD (184) programs.

As the students were studying in the online mode of teaching due to the restrictions of the pandemic and the implementation of social distancing, data were obtained by an online Campus Management Software (CMS) tool. The questionnaire was shared through the personal login IDs of the software. The software was secured for data confidentiality and the information was obtained as anonymous data. The participants were ensured that the information will only be used for research purposes. The language of the questionnaire was English. Students were informed about the objectives and purpose of the study by a description provided before the questionnaire. The consent of participants was taken and students who agreed were asked to fill out the questionnaire during the period of online enrollment. All the preventive measures were followed during the data collection.

Data Collection Instrument

After a thorough literature review, a self-administered questionnaire was developed following the questionnaires of those studies. The draft of the questionnaire was approved by the senior scientists of the institute. After the review, the questionnaire was finalized. A pilot study was performed on 40 students of different degree programs to know the difficulties faced by participants. Participants of the pilot study were able to understand and attempt the questionnaire comfortably. A questionnaire was prepared which was comprised of three parts (i) knowledge about the transmission of COVID-19 disease, knowledge about the prevention of COVID-19 disease, (ii) Attitude about the disease, and (iii) practices about the prevention of disease.

The knowledge section (i) contained 14 questions (K1-K14), the attitude section (ii) contained 7 questions (A1-A7), while the final section on practices (iii) comprised 10 questions (P1-P10). The questions on Knowledge and Practices had three options: Yes, No and Not Sure; though questions of Attitude contained four options: Yes, No, Maybe, and Not Sure. In the questions relating to knowledge, the correct option was scored as one incorrect options were scored as zero. In the attitude segment, $+1$ point was given for true and -1 was given for the false answer. For questions on practices, two points were awarded for the yes option, one for sometimes and zero for no.

Statistical Analysis

The collected data were analyzed with SPSS® software. The number of students answering the particular category variables was converted into a percentage frequency. We used the Chi-square test to analyze the answers of knowledge, attitude, and perception questions across different variables like gender, age, province, degree, number of family members, and area of residence. The statistical significance was considered at $p < 0.05$ while high significance was considered at $p < 0.001$.

RESULTS

Total 97% of the students answered that the etiological agent of COVID-19 is a virus, and that it is a disease of the respiratory system (94%). The majority of the students had the wrong concept that direct contact (87%) can transmit the disease, although they also considered respiratory droplets (92%) to be the mode of transmission of COVID-19. A total of 87% of the students had the view that only older persons or those with weak immunity had a risk of severe symptoms. A total of 95% of students could identify the correct signs and symptoms of the COVID-19 (**Supplementary Table 1**). In total, 37% of students were not sure if COVID-19 can be transmitted by livestock, poultry, and their products, whole 33% of students ruled out the possibility of asymptomatic transmission (**Figure 1**).

The majority of the students believed (97%) that personal hygiene is the best way to prevent the disease, however, they were not sure if they (>9%) and their family members (>15%) were observing the necessary hygienic practices (**Figure 2**). Nearly, 25% of the people in the locality of students were not taking enough precautionary measures. Many students kept visiting their relatives during the lockdown (45%) and their relatives kept visiting them at home (59%), and 10% of students did not wear a mask while visiting outside (**Figure 3**).

Among the Knowledge-based questions, the response of the students differed significantly for the categories of age and Provinces ($p < 0.05$). Students in the age groups of 25–34 and 35–44 had more adequate knowledge (90–91%) as compared to the age group of 18–24 (86%). Participants from KPK had less adequate knowledge (53%) than those of Punjab, Sindh, Balochistan, and Gilgit Baltistan (>80%). The Knowledge response of the participants did not differ significantly by the categories of gender, degree, family members, and area of residence ($p > 0.05$). However, there were fewer correct answers (85%) from the students who had more than 10 family members so the difference in knowledge was significant based on family members. There was not any significant difference in the knowledge of students from cities and villages (**Supplementary Table 2**).

For the attitude based questions, students knew that hygiene is essential for prevention but they had a varied response and were not confident that their family members and people in their locality were observing the precautionary measures. Male students showed significantly more precautionary measures (69%) than female students (66%) ($p < 0.05$). There was a more positive attitude toward the disease in the participants from ICT (77%), and the least positive response was received from the KPK (42%) ($p < 0.05$). No significant difference was found based on the students' degrees in regard to attitude response. Nevertheless, PhD students were following more precautionary measures as compared to Masters students, who were in turn observing more precautions than undergraduate students ($p > 0.05$) (**Supplementary Table 2**). To our surprise, students from villages mentioned that the community in villages was reporting cases more than in cities.

For the practices-based questions, people did not observe the practice of precautionary measures to the extent that they claimed in the knowledge and attitude-based questions. Nearly 92% of students were washing their hands frequently and regularly, however, only 79% were washing their hands for 20 s. Students wearing a face mask before going

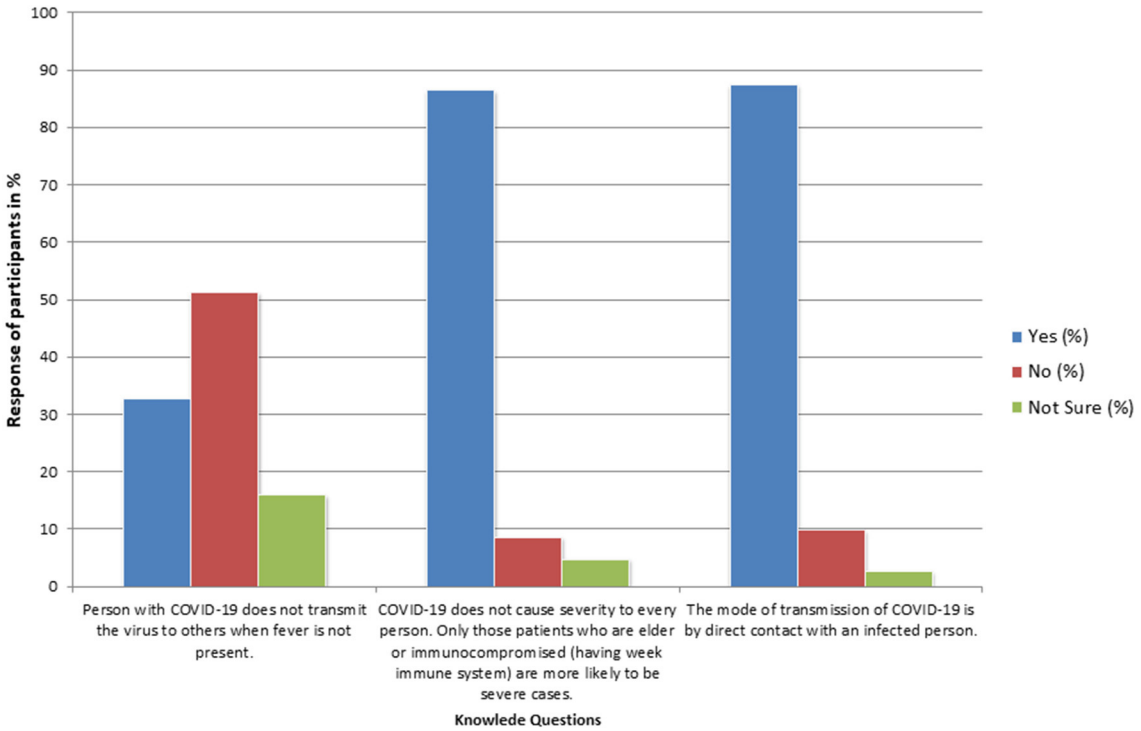

FIGURE 1 | Percentage response of participants on important questions regarding the knowledge for COVID-19 ($N = 3,854$).

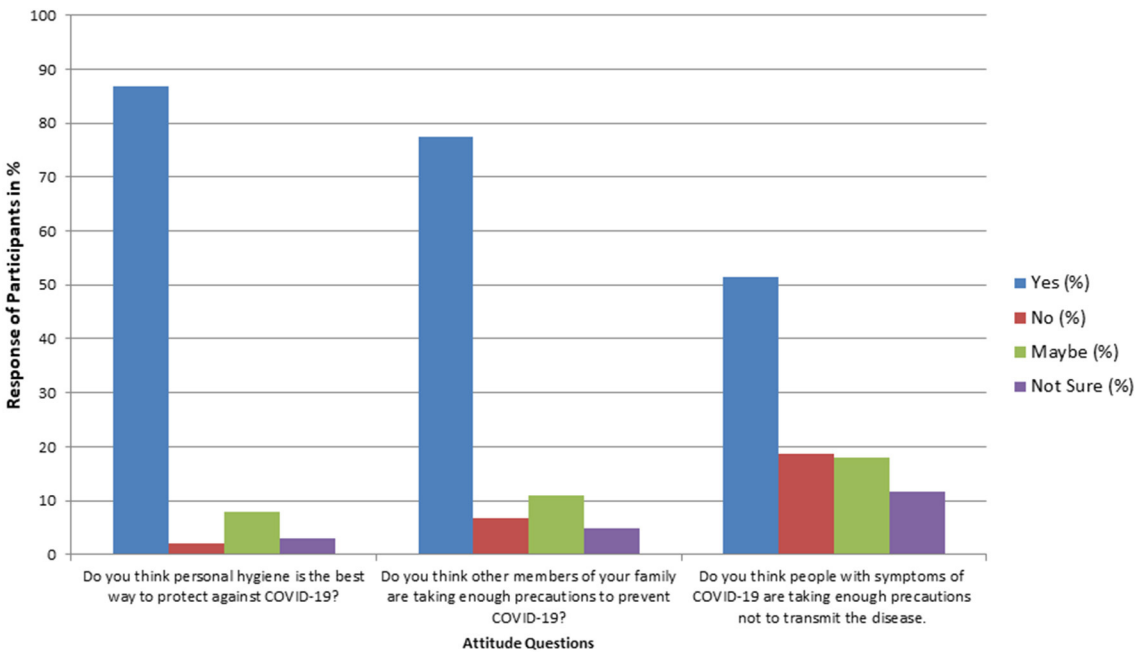

FIGURE 2 | Percentage response of participants on important questions regarding the attitude for COVID-19 ($N = 3,854$).

out totaled 90%. In all 55% were likely to visit relatives during the lockdown. Almost half of the community were not following the guidelines to prevent COVID-19 (**Supplementary Table 1**). The practices for participants from different categories did not differ significantly other than in the provinces. Practices were good in Baluchistan participants (70%) and poor from KPK (30%) ($p < 0.001$) (**Supplementary Table 2**).

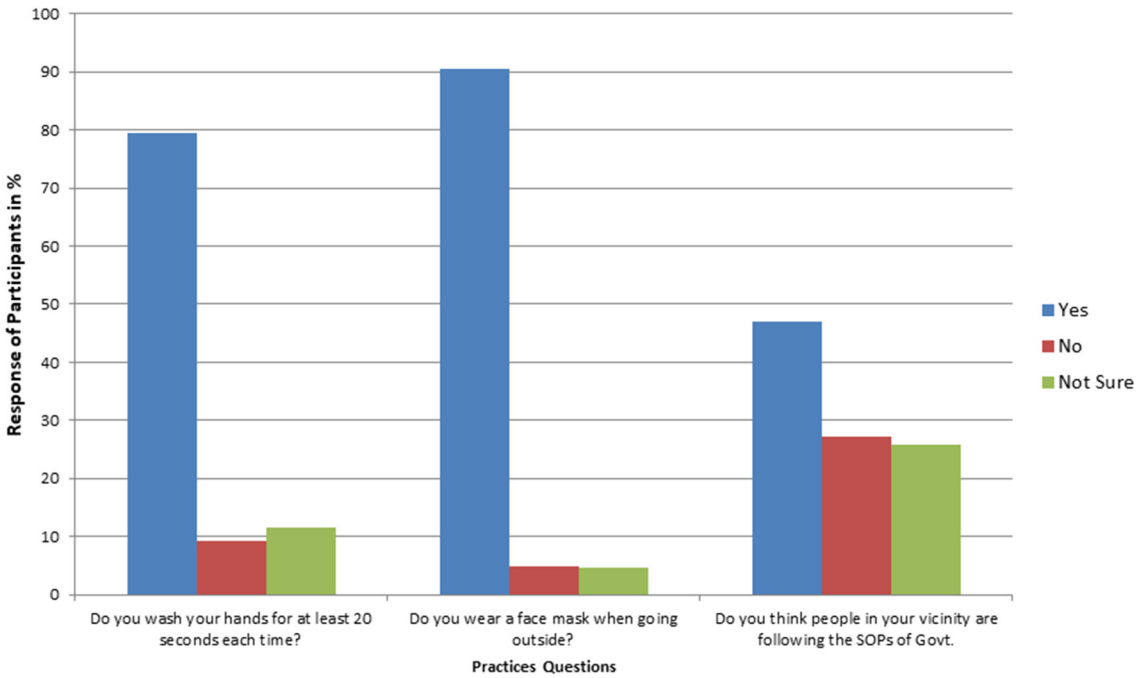

FIGURE 3 | Percentage response of participants on important questions regarding the practices for COVID-19 ($N = 3,854$).

DISCUSSION

The coronavirus disease 2019 (COVID-19) outbreak appeared in the fourth quarter of 2019 from Wuhan, Hubei province, China. Soon after its emergence COVID-19 had spread to most parts of the world and became a threat to public health. COVID-19 lead to significant socioeconomic damages to the whole world. More than 138 million cases have been reported with more than 2.9 million deaths globally till April 15, 2021. Along with the vaccine, strict precautionary measures are the only option to counter the rapid spread of the disease. COVID-19 vaccines are available now from international manufacturers in the developed world; however, they are less accessible in developing countries for mass vaccination for the reason that the government/administration is unable to cope with the cost associated with vaccine procurement from an international source. Therefore, strict precautionary measures need to be opted for in the communities of the developing world to stop the spread of COVID-19. In Pakistan, the first two confirmed COVID-19 cases were reported on February 26, 2020, in two individuals having a travel history to Iran (4). Till October 04, 2021, 1,252,656 cases and 27,947 deaths have been reported by Pakistan.

In this study, students were assessed for knowledge, attitude, and practices toward COVID-19 in UVAS, Lahore, Pakistan. A total of 3,854 students participated in this survey. Among these 1,823 were men and 2,031 were women. This survey showed that most of the students were well informed about COVID-19 and exhibited a proactive approach during the outbreak. This indicates an effective public health campaign of the local government to deliver public health knowledge in the community.

In our study results, 97% of the university students are aware that COVID-19 is a viral disease. However, a previous Pakistani study found that 59.3% of the survey participants from the general public know that SARS-CoV-2 causes COVID-19 (14). The difference in results of both studies could be due to the fact that the participants of the current study are students from medical, health, and allied sciences backgrounds. Therefore, their knowledge and understanding of COVID-19 is much better than that of the general population. However, our findings are justified by the studies from China and Japan that depict the critical role of education in the understanding of COVID (15, 16). Nearly 57% of the participants were satisfied with the government efforts to control the current pandemic. Interestingly, 50% of the participants believe that the government did not handle the pandemic crisis well, which is in line with one of the previous studies from the general population where only 48% of the participants were satisfied with the government efforts to control COVID-19 (14).

The majority of the participants in the current survey are well informed about the transmission of COVID-19. Similar knowledge about the transmission of COVID-19 was observed in KAP studies from Pakistan and China (14, 16). A majority of survey participants (95%) believe that frequent hand washing with soap and wearing masks are the best practices to avoid COVID-19 infection. The above findings are supported by three other Pakistani studies (17–19). We found 92% of the participants believe that only systematic and supportive treatment is considered best for patients who have recovered

from COVID-19. Our results agree with the other study conducted in Nepal (20). The majority of the participants (73%) know that COVID-19 is not transmitted by animals, especially poultry, livestock, and their products. This result clarifies that the students do not believe in the rumors that animal products can be a source of COVID-19 viral spread. Most of the participants (95%) believe that social distancing and avoiding crowded palaces are a good way to avoid COVID-19 infection. Our results agree with previous studies conducted in China, the UK, South Korea, Indonesia, and the United Arab Emirates on KAP among students during various outbreaks (11, 15, 16, 21). In this study, social media was the leading source of information spread about coronavirus, outstripping print and electronic media. In the same line, social media remains the largest source of information in other studies from different countries (22, 23). This study has shown that participating women had more knowledge and were more aware of disease knowledge in comparison to men. Moreover, women proved superior to men in terms of practicing social distancing, hand hygiene, and wearing masks. A similar leading behavior in women was observed in the previous studies during various outbreaks (16).

Most of the participants were agreed that they were taking ample precautions to tackle this outbreak. But only half of the participants believed that other people in their vicinity were taking precautions, therefore nearly 50% of the participants believed that people in their vicinity are not taking precautions for COVID-19. This depicts that strict actions should be taken using law enforcement for the implementation of COVID-19 preventive measures. Moreover, only half of the participants agreed that COVID-19 patients were taking enough precautions during the course of the disease. Similar results were observed in a survey conducted on a different population (23). This shows that government needs to launch a campaign using social media about the precautions that should be taken by the COVID-19 patients. This will be helpful to reduce the spread of the disease in the community. Interestingly, 50% of the participants had visited the relatives during the lockdown period, which shows that people are not taking preventive measures seriously, which may lead to an increase in the number of cases in the near future.

Nearly 80% of the participants were confident that Pakistan can counter the disease spread, however, more than 30% of the participants were not satisfied with the approach of the government in handling COVID-19. Almost the same number of participants wanted the government to revise its strategies in controlling COVID-19 in the country. Currently, Pakistan has been adopting the strategy of smart lockdown, however the survey participants believe that a complete lockdown strategy is better than the smart lockdown strategy. Additionally, 90% of the participants believe that country will win the battle against COVID-19. In the culmination of the above survey findings, it is concluded that government should use social media platforms to spread knowledge about COVID-19 disease prevention in society and formulate a comprehensive program to deal with the COVID-19 pandemic.

The major limitation of this study is that the sample size is limited to the students of one government institution only, hence the results based on the current survey could not be generalized to the whole population of the country, however, current study findings can predict the thoughts of the university students. Moreover, the present study data will be helpful for the country to focus on the gaps that need to be strengthened to curb this disease.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Institutional Ethical Committee of UVAS, Lahore. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

TY and MN: conceptualization. MN and SR: designing of KAP Survey Form. ZA and MSa: acquisition of data. SR, MAs, and NM: analysis and interpretation of data. SR, MN, MAs, MSh, MAl, NM, RL, and TY: drafting the article and revision. All authors have approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.697686/full#supplementary-material

REFERENCES

1. Tang JW, Tambyah PA, Hui DSC. Emergence of a novel coronavirus causing respiratory illness from Wuhan, China. *J Infect.* (2020) 80:350–71. doi: 10.1016/j.jinf.2020.01.014
2. Gorbalenya A, Baker S, Baric R, de Groot R, Drosten C, Gulyaeva A, et al. Coronaviridae study group of the international committee on taxonomy of viruses. The species severe acute respiratory syndrome-related coronavirus: classifying 2019-nCoV and naming it SARS-CoV-2. *Nat microbiol.* (2020) 2020:3–4. doi: 10.1038/s41564-020-0695-z
3. Guan WJ, Ni ZY, Hu Y, Liang WH, Ou CQ, He JX, et al. Clinical characteristics of coronavirus disease 2019 in China. *N Engl J Med.* (2020) 382:1708–20. doi: 10.1056/NEJMoa2002032
4. Abid K, Bari YA, Younas M, Tahir Javaid S, Imran A. Progress of COVID-19 epidemic in Pakistan. *Asia Pac J*

Public Health. (2020) 32:154–6. doi: 10.1177/1010539520927259
5. Lauer SA, Grantz KH, Bi Q, Jones FK, Zheng Q, Meredith HR, et al. The incubation period of coronavirus disease 2019 (COVID-19) from publicly reported confirmed cases: estimation and application. *Ann Intern Med.* (2020) 172:577–82. doi: 10.1101/2020.02.02.20020016
6. Tabary M, Khanmohammadi S, Araghi F, Dadkhahfar S, Tavangar SM. Pathologic features of COVID-19: a concise review. *Pathol Res Pract.* (2020) 216:153097. doi: 10.1016/j.prp.2020.153097
7. Hakim AS, Symae SM, Shehata MM, Sayed ATA. The battle with COVID-19: insight on external intervention and future vaccination. *South Asian Journal of Research in Microbiology.* (2020) 7:46–61. doi: 10.9734/sajrm/2020/v7i230169
8. Ali MY, Bhatti R. COVID-19 (coronavirus) pandemic: information sources channels for the public health awareness. *Asia Pac J Public Health.* (2020) 32:168–9. doi: 10.1177/1010539520927261
9. O'Connor C, Murphy M. Going viral: doctors must tackle fake news in the covid-19 pandemic. *BMJ.* (2020) 369:m1587. doi: 10.1136/bmj.m1587
10. Puspitasari IM, Yusuf L, Sinuraya RK, Abdulah R, Koyama H. Knowledge, attitude, and practice during the COVID-19 pandemic: a review. *J Multidiscip Healthc.* (2020) 13:727–33. doi: 10.2147/JMDH.S265527
11. Saefi M, Fauzi A, Kristiana E, Adi WC, Muchson M, Setiawan ME, et al. Survey data of COVID-19-related knowledge, attitude, and practices among Indonesian undergraduate students. *Data Brief.* (2020) 31:105855. doi: 10.1016/j.dib.2020.105855
12. Al-Hanawi MK, Angawi K, Alshareef N, Qattan AMN, Helmy HZ, Abudawood Y, et al. Knowledge, attitude and practice toward COVID-19 among the public in the kingdom of Saudi Arabia: a cross-sectional study. *Front Public Health.* (2020) 8:217. doi: 10.3389/fpubh.2020.00217
13. Habib MA, Dayyab FM, Iliyasu G, Habib AG. Knowledge, attitude and practice survey of COVID-19 pandemic in Northern Nigeria. *PLoS ONE.* (2021) 16:e0245176. doi: 10.1371/journal.pone.0245176
14. Rehman R, Jawed S, Ali R, Noreen K, Baig M, Baig J. COVID-19 pandemic awareness, attitudes, and practices among the Pakistani general public. *Front Public Health.* (2021) 9:588537. doi: 10.3389/fpubh.2021.588537
15. Hatabu A, Mao X, Zhou Y, Kawashita N, Wen Z, Ueda M, et al. Knowledge, attitudes, and practices toward COVID-19 among university students in Japan and associated factors: an online cross-sectional survey. *PLoS ONE.* (2020) 15:e0244350. doi: 10.1371/journal.pone.0244350
16. Peng Y, Pei C, Zheng Y, Wang J, Zhang K, Zheng Z, et al. A cross-sectional survey of knowledge, attitude and practice associated with COVID-19 among undergraduate students in China. *BMC Public Health.* (2020) 20:1292. doi: 10.1186/s12889-020-09392-z
17. Paul SS, Deb SM, Dey A, Somvanshi SP, Singh D, Rathore R, et al. 16S rDNA analysis of archaea indicates dominance of Methanobacterium and high abundance of Methanomassiliicoccaceae in rumen of Nili-Ravi buffalo. *Anaerobe.* (2015) 35:3–10. doi: 10.1016/j.anaerobe.2015.06.002
18. Salman M, Mustafa ZU, Asif N, Zaidi HA, Hussain K, Shehzadi N, et al. Knowledge, attitude and preventive practices related to COVID-19: a cross-sectional study in two Pakistani university populations. *Drugs Ther Perspect.* (2020) 36:1–7. doi: 10.1007/s40267-020-00737-7
19. Faisal S, Khotib J, Zairina E. Knowledge, attitudes, and practices (KAP) towards COVID-19 among university students in Pakistan: a cross-sectional study. *J Basic Clin Physiol Pharmacol.* (2021) 32:681–6. doi: 10.1515/jbcpp-2020-0436
20. Sah GS, Shrestha G, Dhakal A, Mulmi R, Sapkota A, Poudel S. Knowledge, attitudes, and practices of cancer patients towards COVID-19: a cross-sectional study in central Nepal. *Cancer Manag Res.* (2020) 12:10173–80. doi: 10.2147/CMAR.S271910
21. Hasan H, Raigangar V, Osaili T, Neinavaei NE, Olaimat AN, Aolymat I, et al. Cross-sectional study on university students' knowledge, attitudes, and practices toward COVID-19 in the United Arab Emirates. *Am J Trop Med Hyg.* (2021) 104:75–84. doi: 10.4269/ajtmh.20-0857
22. Dkhar SA, Quansar R, Saleem SM, Khan SMS. Knowledge, attitude, and practices related to COVID-19 pandemic among social media users in J&K, India. *Indian J Public Health.* (2020) 64:S205–S10. doi: 10.4103/ijph.IJPH_469_20
23. Mahmood S, Hussain T, Mahmood F, Ahmad M, Majeed A, Beg BM, et al. Attitude, perception, and knowledge of COVID-19 among general public in Pakistan. *Front Public Health.* (2020) 8:602434. doi: 10.3389/fpubh.2020.602434

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Public Opinion on Priorities Toward Fair Allocation of Ventilators During COVID-19 Pandemic: A Nationwide Survey

*Mohsen Abbasi-Kangevari, Shahnam Arshi, Hossein Hassanian-Moghaddam and Ali-Asghar Kolahi**

Social Determinants of Health Research Center, Shahid Beheshti University of Medical Sciences, Tehran, Iran

Background: The rapidly growing imbalance between supply and demand for ventilators during the COVID-19 pandemic has highlighted the principles for fair allocation of scarce resources. Failing to address public views and concerns on the subject could fuel distrust. The objective of this study was to determine the priorities of the Iranian public toward the fair allocation of ventilators during the COVID-19 pandemic.

Methods: This anonymous community-based national study was conducted from May 28 to Aug 20, 2020, in Iran. Data were collected via the Google Forms platform, using an online self-administrative questionnaire. The questionnaire assessed participants' assigned prioritization scores for ventilators based on medical and non-medical criteria. To quantify participants' responses on prioritizing ventilator allocation among sub-groups of patients with COVID-19 who need mechanical ventilation scores ranging from −2, very low priority, to +2, very high priority were assigned to each response.

Results: Responses of 2,043 participants, 1,189 women, and 1,012 men, were analyzed. The mean (SD) age was 31.1 (9.5), being 32.1 (9.3) among women, and 29.9 (9.6) among men. Among all participants, 274 (13.4%) were healthcare workers. The median of assigned priority score was zero (equal) for gender, age 41–80, nationality, religion, socioeconomic, high-profile governmental position, high-profile occupation, being celebrities, employment status, smoking status, drug abuse, end-stage status, and obesity. The median assigned priority score was +2 (very high priority) for pregnancy, and having <2 years old children. The median assigned priority score was +1 (high priority) for physicians and nurses of patients with COVID-19, patients with nobel research position, those aged<40 years, those with underlying disease, immunocompromise status, and malignancy. Age>80 was the only factor participants assigned −1 (low priority) to.

Conclusions: Participants stated that socioeconomic factors, except for age>80, should not be involved in prioritizing mechanical ventilators at the time of resources scarcity. Front-line physicians and nurses of COVID-19 patients, pregnant mothers, mothers who had children under 2 years old were given high priority.

Keywords: coronavirus infections, health care rationing, ethics, health policy, resource allocation, SARS-CoV-2, mechanical ventilators

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****Correspondence:***
Ali-Asghar Kolahi
a.kolahi@sbmu.ac.ir

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INTRODUCTION

The coronavirus disease (COVID-19) pandemic continues to place extraordinary demands on healthcare systems and has resulted in severe shortages of essential resources and services (1). In the pandemic's early days, the face masks' shortages became increasingly concerning (2). Nevertheless, among all the medical resources, scarcity of ventilators could be the most challenging, as there is typically limited time if mechanical ventilation is essential (3). Another limiting factor is the availability of trained healthcare professionals to operate ventilators safely, especially considering the catastrophic casualty of COVID-19 of healthcare professionals (4).

The rapidly growing imbalance between supply and demand for ventilators has raised the question of how to allocate them during the COVID-19 pandemic fairly. Research has been ongoing to investigate the main principles for allocating scarce medical resources during pandemics (5–7). In this sense, physicians should not be faced with situations where they must decide which patient to treat due to the risk of human error and the life-long emotional toll (8). Therefore, prioritization recommendations and guidelines have been developed in the hope of helping physicians, especially those less experienced, with the real-time decision-making process based on the resources and contexts (1, 9).

The proposed principles for resource allocation could become controversial in the eyes of the public. Even the seemingly most holistic approaches for resource allocation proposed by healthcare systems could result in inequalities among patients (10). This could raise serious concerns about their fairness and result in loss of public trust in health care systems. Therefore, people need to be involved in developing and evaluating such policies as stakeholders. Failing to address public views and concerns could fuel distrust and negatively affect compliance to health-promoting measures (11).

The objective of this study was to determine the priorities of the Iranian public toward the fair allocation of ventilators during the COVID-19 pandemic via an online survey.

METHODS

This community-based national study was approved by the Ethical Committee of Shahid Beheshti University of Medical Sciences under code IR.SBMU.RETECH.REC.1399.167. Participation was anonymous and upon the participant's own decision.

Setting and Sampling

This anonymous network-sampling survey was conducted from May 28 to Aug 20, 2020, in Iran. Data were collected via the Google Forms platform, using an online self-administrative questionnaire. An invitation post with a link to the questionnaire was circulated online on popular social networks in Iran, including Telegram, Instagram, WhatsApp, Twitter, and LinkedIn. Participants were Iranian adults currently living in Iran who agreed to participate in the study.

TABLE 1 | Socio-demographic characteristics of participants.

Variable	*N* (%)
Sex	
Female	1,122 (54.9)
Male	921 (45.1)
Marital status	
Never married	823 (40.2)
Engaged	45 (2.2)
Married	1,127 (55.2)
Divorced	40 (2.0)
Widowed	8 (0.4)
Ethnicity	
Fars	1,145 (56.1)
Turk/Azari	449 (22.0)
Kurd	129 (6.3)
Lor	88 (4.3)
Other	232 (11.3)
Literacy	
High school diploma	475 (23.2)
Associate degree	121 (5.9)
Bachelor	861 (42.1)
Master	375 (18.4)
Ph.D. and higher	197 (9.8)
Other	14 (5.6)
Healthcare worker	
Yes	274 (13.4)
No	1,769 (86.6)

Variables and the Questionnaire

Variables included socio-demographic characteristics and the criteria for prioritizing the ventilators during the pandemic. Socio-demographic characteristics included participants' age, sex, ethnicity, religion, literacy, the province of residence in Iran, being a healthcare professional, marital status, number of alive children, smoking status, having underlying diseases, previous history of COVID-19, being tested for COVID-19, being admitted for COVID-19, and knowing someone with COVID-19.

The criteria for prioritizing the ventilators during the pandemic included age, nationality, religion, occupation, socioeconomic status, smoking status, drug abuse, and underlying diseases.

A panel of ten experts, including two public health experts, two anesthesiologists, two emergency medicine experts, two pulmonologists, and two infectious diseases specialists, evaluated the questionnaire's content validity. An item discrimination analysis was conducted for each scale to eliminate too tricky or easy items. Factor analysis was performed for factor structure. Separate test-retest over 2 weeks were held for the three scales of the questionnaire. The test-retest correlation was 0.91;

Abbreviations: COVID-19, Coronavirus disease; SD, Standard deviation; 95% CI, 95% confidence interval; IQR, Interquartile range; ANOVA, One-way analysis of variance.

Kuder-Richardson-20 was used to prevent internal consistency overestimation; the coefficient was 0.87. The pilot survey was conducted on twenty men, and twenty women recruited online via convenience sampling method.

Data Analysis

To quantify participants' responses on prioritizing ventilator allocation among sub-groups of patients with COVID-19 who need mechanical ventilation scores were assigned to each response: "very low priority" was considered as "−2," "low priority" was considered as "−1," "equal priority" was considered as "0," "high priority" was considered as "+1," and "very high priority" was considered as "+2." To measure the distribution of responses, mean, standard deviation (SD), 95% confidence interval (95% CI), median, interquartile range (IQR), mode, and skewness were reported. Categorical variables were analyzed by the Chi-Square test. For analyzing the differences among means of two groups and three groups or more, independent-sample *t*-test and one-way analysis of variance (ANOVA) test were used. Statistical analyses were performed using IBM SPSS Statistics 21. A probability level of <0.05 was considered significant.

RESULTS

Responses of 2,043 participants were analyzed. There were no missing values. The mean (SD) age was 31.1 (9.5) [range = 18–80, being 32.1 (9.3) among women, and 29.9 (9.6) among men]. Among participants, 259 (12.7) smoked. Other socio-demographic characteristics are presented in **Table 1**.

Among all participants, 151 (6.9%) said they had a history of COVID-19, 268 (12.2%) said they smoked, 332 (15.1%) reported having underlying diseases, 13 (0.6%) reported being intubated due to COVID-19, and 899 (40.8) said they knew someone who had been admitted due to COVID-19.

The majority of participants believed that socioeconomic determinants including gender, age below 80, nationality, religion, and employment should not be involved in prioritizing mechanical ventilators at the time of resource scarcity. Participants also did not consider smoking and

TABLE 2 | Participants' responses on prioritizing ventilator allocation among sub-groups of patients with COVID-19 who need mechanical ventilation.

Factor	Very low priority (n%)	Low priority (n%)	Equal priority (n%)	High priority (n%)	Very high priority (n%)
Female gender	12 (0.6)	8 (0.4)	1,515 (74.2)	269 (13.2)	239 (11.6)
Age (years)					
<40	14 (0.7)	99 (4.8)	870 (42.6)	538 (26.3)	522 (25.6)
41–60	15 (0.8)	74 (3.6)	936 (45.8)	756 (37.0)	262 (12.8)
61–80	123 (6.0)	483 (23.6)	801 (39.2)	287 (14.1)	349 (17.1)
>80	585 (28.6)	463 (22.7)	534 (26.1)	164 (8.0)	297 (14.6)
Iranian nationality	26 (1.3)	30 (1.5)	1,300 (63.6)	213 (10.4)	474 (23.2)
Muslim religion	61 (3.0)	13 (0.6)	1,792 (87.7)	64 (3.1)	113 (5.6)
Physician profession					
of COVID-19 patients	10 (0.5)	6 (0.3)	509 (24.9)	578 (28.3)	940 (46.0)
not for COVID-19 patients	26 (1.3)	30 (1.5)	1,388 (67.9)	427 (20.9)	172 (8.4)
Nurse profession					
of COVID-19 patients	9 (0.4)	8 (0.4)	490 (24.0)	651 (31.9)	885 (43.3)
not for COVID-19 patients	25 (1.2)	26 (1.3)	1,404 (68.7)	425 (20.8)	163 (8.0)
Other healthcare professionals	27 (1.3)	23 (1.1)	1,535 (75.1)	324 (15.9)	134 (6.6)
High socioeconomic status	142 (7.0)	86 (4.2)	1,743 (85.3)	43 (2.1)	29 (1.4)
High-profile governmental position	637 (31.2)	124 (6.1)	1,182 (57.9)	62 (3.0)	38 (1.8)
Nobel research position	Zero	Zero	939 (42.6)	631 (28.7)	631 (28.7)
High-profile occupation	77 (3.8)	39 (1.9)	1,560 (76.3)	274 (13.4)	93 (4.6)
Celebrities	87 (4.3)	46 (2.3)	1,735 (84.9)	123 (6.0)	52 (2.5)
Unemployment	24 (1.2)	24 (1.2)	1,799 (88.1)	97 (4.7)	99 (4.8)
Pregnancy	9 (0.4)	3 (0.1)	198 (9.7)	651 (31.9)	1182 (57.9)
Having <2 years old child	7 (0.3)	Zero	274 (13.4)	655 (32.1)	1107 (54.2)
Smoking	114 (5.6)	212 (10.4)	1,517 (74.3)	116 (5.7)	84 (4.0)
Drug abuse	332 (16.3)	390 (19.0)	1,209 (59.2)	73 (3.6)	39 (1.9)
Having underlying disease	15 (0.7)	54 (2.6)	564 (27.6)	815 (39.9)	595 (29.2)
Immunocompromise	30 (1.5)	70 (3.4)	509 (24.9)	753 (36.9)	681 (33.3)
Malignancy	78 (3.8)	172 (8.4)	520 (25.5)	639 (31.3)	634 (31.0)
End-stage status	428 (20.9)	510 (25.0)	802 (39.3)	137 (6.7)	166 (8.1)
Obesity	16 (0.8)	43 (2.1)	1,649 (80.7)	210 (10.3)	125 (6.1)

TABLE 3 | Dispersion measures of participants' responses on prioritizing ventilator allocation among sub-groups of patients with COVID-19 who need mechanical ventilation.

Factor	Mode	Mean (SD)	95% CI	Median (IQR)	Skewness
Female gender	Equal	0.4 (0.7)	0.3 to 0.4	0 (0 to 1)	1.2
Age (years)					
<40	Equal	0.7 (0.9)	0.7 to 0.8	1 (0,2)	Zero
41–60	Equal	0.6 (0.8)	0.5 to 0.6	0 (0,1)	0.1
61–80	Equal	0.1 (1.2)	0.1 to 0.2	0 (−1,1)	0.2
>80	Very low	−0.4 (1.4)	(−0.5) to (−0.3)	−1 (−2,0)	0.5
Iranian nationality	Equal	0.5 (0.9)	0.5 to 0.6	0 (0,1)	0.5
Muslim religion	Equal	0.1 (0.6)	0.06 to 0.11	0 (0,0)	0.7
Physician profession					
of COVID-19 patients	Very high	1.2 (0.9)	1.1 to 1.2	1 (0,2)	−0.6
not for COVID-19 patients	Equal	0.3 (0.7)	0.3 to 0.4	0 (0,1)	0.6
Nurse profession					
of COVID-19 patients	Very high	1.2 (0.8)	1.1 to 1.2	1 (1,2)	−0.6
not for COVID-19 patients	Equal	0.3 (0.7)	0.3 to 0.4	0 (0,1)	0.7
Other healthcare professionals	Equal	0.3 (0.7)	0.2 to 0.3	0 (0,0)	0.8
High socioeconomic status	Equal	−0.1 (0.6)	(−0.2) to (−0.1)	0 (0,0)	−1.2
High-profile governmental position	Equal	−0.6 (1)	(−0.6) to (−0.5)	0 (−2,0)	−0.2
Nobel research position	Equal	0.9 (0.8)	0.8 to 0.9	1 (0,2)	0.3
High-profile occupation	Equal	0.1 (0.7)	0.1 to 0.2	0 (0,0)	Zero
Celebrities	Equal	0 (0.6)	−0.01 to 0.04	0 (0,0)	−0.4
Unemployment	Equal	0.1 (0.5)	0.08 to 0.13	0 (0,0)	1.4
Pregnancy	Very high	1.5 (0.7)	1.4 to 1.5	2 (1,2)	−1.3
Having <2 years old child	Very high	1.4 (0.7)	1.3 to 1.4	2 (1,2)	−1
Smoking	Equal	−0.1 (0.7)	(−0.1) to 0	0 (0,0)	−0.1
Drug abuse	Equal	−0.4 (0.9)	(−0.5) to (−0.4)	0 (−1,0)	−0.3
Having underlying disease	High	0.9 (0.9)	0.9 to 1	1 (0,2)	−0.5
Immunocompromise	High	1 (0.9)	0.9 to 1	1 (0,2)	−0.6
Malignancy	High	0.8 (1.1)	0.7 to 0.8	1 (0,2)	−0.6
End-stage status	Equal	−0.4 (1.1)	(−0.5) to (−0.4)	0 (−1,0)	0.4
Obesity	Equal	0.2 (0.6)	0.17 to 0.22	0 (0,0)	1.3

drug abuse to be determinants of prioritization. Nevertheless, participants responded that patients aged above 80 receive very low priority. Front-line physicians and nurses of COVID-19 patients were given very high priority, along with pregnant mothers and those who had children under 2 years old. While end-stage status and obesity were considered unimportant in resource allocation, having underlying diseases, malignancy, and immunocompromised status were given high priority (**Tables 2**, **3**).

Compared with men, women assigned higher scores to the female gender, age 41–60, having underlying disease, being immunocompromised, having malignancy, or having an end-stage disease. In addition, they assigned lower scores to Iranian nationality compared with men (**Table 4**).

Among all participants, 274 (13.4%) were healthcare workers. Most healthcare workers believed that socioeconomic determinants, including gender, age below 80, nationality, religion, and employment, should not determine ventilator prioritization. They also did not consider smoking and drug abuse to be determinants of prioritization. Although they said that patients with underlying diseases, immunocompromise, or malignancy should receive the same priority as others, they assigned very low scores to patients with end-stage disease.

Compared with non-healthcare workers, healthcare workers assigned higher scores to age<40, healthcare workers, and Nobel researchers. They also assigned lower scores to having underlying disease, being immunocompromised, having malignancy, or having an end-stage disease (**Table 5**).

No correlations were observed with participants' responses on resources allocation and their age, ethnicity, religion, literacy, the province of residence in Iran, marital status, number of alive children, smoking status, having underlying diseases, previous history of COVID-19, being tested for COVID-19, being admitted for COVID-19, and knowing someone with COVID-19.

DISCUSSION

The study showed that most participants believed that socioeconomic factors, including gender, age below 80,

TABLE 4 | The mean priority score assigned to each sub-group of patients with COVID-19 among men and women.

Factor	Women (n = 1,189)		Men (n = 1,012)		p
	Mean (SD)	95% CI	Mean (SD)	95% CI	
Female gender	0.4 (0.7)	0.4 to 0.4	0.3 (0.7)	0.2 to 0.3	<0.001
Age (years)					
<40	0.8 (0.9)	0.7 to 0.8	0.6 (0.9)	0.6 to 0.7	N/S*
41–60	0.6 (0.8)	0.6 to 0.7	0.5 (0.8)	0.4 to 0.5	<0.001
61–80	0.2 (1.1)	0.1 to 0.2	0.1 (1.2)	0 to 0.2	N/S
>80	−0.4 (1.3)	(−0.5) to (−0.3)	−0.4 (1.5)	(−0.5) to (−0.3)	N/S
Iranian nationality	0.5 (0.9)	0.4 to 0.5	0.6 (0.9)	0.5 to 0.7	<0.001
Muslim religion	0.1 (0.5)	0.1 to 0.1	0.1 (0.7)	0 to 0.1	N/S
Physician profession					
of COVID-19 patients	1.2 (0.8)	1.1 to 1.2	1.2 (0.9)	1.2 to 1.3	N/S
not for COVID-19 patients	0.4 (0.7)	0.3 to 0.4	0.3 (0.8)	0.3 to 0.4	N/S
Nurse profession					
of COVID-19 patients	1.1 (0.8)	1.1 to 1.2	1.2 (0.9)	1.1 to 1.2	N/S
not for COVID-19 patients	0.3 (0.7)	0.3 to 0.4	0.3 (0.7)	0.3 to 0.4	N/S
Other healthcare professionals	0.3 (0.6)	0.3 to 0.3	0.2 (0.7)	0.2 to 0.3	0.004
High socioeconomic status	−0.1 (0.5)	(−0.1) to (−0.1)	−0.2 (0.7)	(−0.2) to (−0.1)	N/S
High-profile governmental position	−0.5 (0.9)	(−0.6) to (−0.5)	−0.7 (1.1)	(−0.7) to (−0.6)	0.04
Nobel research position	0.8 (0.8)	0.8 to 0.9	0.9 (0.8)	0.9 to 1	<0.001
High-profile occupation	0.1 (0.6)	0.1 to 0.2	0.1 (0.8)	0.1 to 0.2	N/S
Celebrities	0.1 (0.5)	0 to 0.1	0 (0.7)	(−0.1) to 0	0.01
Unemployment	0.1 (0.5)	0.1 to 0.1	0.1 (0.6)	0.1 to 0.1	N/S
Pregnancy	1.5 (0.7)	1.4 to 1.5	1.5 (0.7)	1.4 to 1.5	N/S
Having <2 years old child	1.4 (0.7)	1.4 to 1.5	1.3 (0.8)	1.3 to 1.4	<0.001
Smoking	0 (0.7)	(−0.1) to 0	−0.1 (0.8)	(−0.2) to (−0.1)	<0.001
Drug abuse	−0.4 (0.9)	(−0.5) to (−0.4)	−0.5 (0.9)	(−0.5) to (−0.4)	0.02
Having underlying disease	1 (0.8)	1 to 1.1	0.8 (0.9)	0.8 to 0.9	<0.001
Immunocompromise	1.1 (0.9)	1 to 1.1	0.8 (1)	0.8 to 0.9	<0.001
Malignancy	0.9 (1)	0.9 to 1	0.6 (1.1)	0.5 to 0.7	<0.001
End-stage status	−0.3 (1.1)	(−0.4) to (−0.3)	−0.6 (1.2)	(−0.6) to (−0.5)	<0.001
Obesity	0.2 (0.6)	0.2 to 0.3	0.1 (0.6)	0.1 to 0.2	<0.001

Not significant.

nationality, religion, employment; smoking and drug abuse; medical conditions including end-stage status, and obesity, should not be involved in prioritizing mechanical ventilators at the time of resources scarcity. Front-line physicians and nurses of COVID-19 patients, pregnant mothers, mothers who had children under 2 years old, patients with underlying diseases, malignancy, or immunocompromised status were given high priority. On the contrary, participants assigned age above 80 very low priority.

Participants did not consider age <80 to be a deciding factor in resource allocation. However, a study on the general public in the US reported that participants favored allocating more ventilators to patients of younger age groups (10). This conforms with the current proposed guidelines that prioritize younger patients to receive scarce medical resources (9, 12, 13). Nevertheless, there are controversies in the literature and ethical guidelines regarding using age as a screening factor for resource allocation (14). Although higher age groups are associated with higher mortality rates due to COVID-19 (15, 16), poor outcomes among the elderly could be attributable to comorbidities with a higher prevalence among older age groups (16, 17). Thus, some studies argue that age should only be used as a tiebreaker criterion among patients with similar severity of COVID-19, not the only criterion to determine screening decisions (18–20). In this context, it is the duty of health authorities and the media not to disseminate fear among the older age groups and ease their concerns via effective communication.

The majority of participants agreed that ventilators should not be allocated based on non-clinical irrelevant aspects. They did not consider gender, employment, financial condition, or social relations as deciding factors. Moreover, almost 90% of participants said that religion should not be considered a prioritization factor, which is satisfactory given that crises like the COVID-19 pandemic tend to fuel conflicts. Some two-thirds

TABLE 5 | The mean priority score assigned to each sub-group of patients with COVID-19 among healthcare workers and non-healthcare workers.

Factor	Healthcare workers (n = 274)		Non-healthcare workers (n = 1,769)		p
	Mean (SD)	95% CI	Mean (SD)	95% CI	
Female gender	0.3 (0.6)	0.2 to 0.4	0.4 (0.7)	0.3 to 0.4	N/S
Age (years)					
<40	0.8 (0.9)	0.7 to 0.9	0.7 (0.9)	0.7 to 0.7	0.02
41–60	0.6 (0.8)	0.6 to 0.7	0.6 (0.8)	0.5 to 0.6	N/S
61–80	0.1 (1)	(−0.1) to 0.2	0.1 (1.2)	0.1 to 0.2	N/S
>80	−0.6 (1.2)	(−0.7) to (−0.5)	−0.4 (1.4)	(−0.4) to (−0.3)	0.01
Iranian nationality	0.5 (0.8)	0.4 to 0.6	0.5 (0.9)	0.5 to 0.6	N/S
Muslim religion	0 (0.5)	0 to 0.1	0.1 (0.6)	0.1 to 0.1	N/S
Physician profession					
of COVID-19 patients	1.3 (0.8)	1.2 to 1.4	1.2 (0.9)	1.1 to 1.2	N/S
not for COVID-19 patients	0.6 (0.8)	0.6 to 0.7	0.3 (0.7)	0.3 to 0.3	<0.001
Nurse profession					
of COVID-19 patients	1.2 (0.8)	1.1 to 1.3	1.2 (0.8)	1.1 to 1.2	N/S
not for COVID-19 patients	0.6 (0.8)	0.5 to 0.7	0.3 (0.7)	0.3 to 0.3	<0.001
Other healthcare professionals	0.5 (0.7)	0.4 to 0.6	0.2 (0.6)	0.2 to 0.2	<0.001
High socioeconomic status	0 (0.6)	(−0.1) to 0	−0.1 (0.6)	(−0.2) to (−0.1)	<0.001
High-profile governmental position	−0.5 (1)	(−0.6) to (−0.4)	−0.6 (1)	(−0.7) to (−0.6)	N/S
Nobel research position	1.1 (0.9)	1 to 1.2	0.8 (0.8)	0.8 to 0.9	<0.001
High-profile occupation	0.3 (0.7)	0.2 to 0.3	0.1 (0.7)	0.1 to 0.2	<0.001
Celebrities	0.2 (0.7)	0.1 to 0.3	0 (0.6)	0 to 0	<0.001
Unemployment	0.1 (0.5)	0 to 0.2	0.1 (0.5)	0.1 to 0.1	N/S
Pregnancy	1.4 (0.7)	1.3 to 1.5	1.5 (0.7)	1.4 to 1.5	N/S
Having <2 years old child	1.3 (0.8)	1.2 to 1.4	1.4 (0.7)	1.4 to 1.4	0.02
Smoking	−0.1 (0.7)	(−0.2) to 0	−0.1 (0.7)	(−0.1) to 0	N/S
Drug abuse	−0.5 (0.9)	(−0.6) to (−0.4)	−0.4 (0.9)	(−0.5) to (−0.4)	N/S
Having underlying disease	0.8 (0.9)	0.7 to 0.9	1 (0.9)	0.9 to 1	<0.001
Immunocompromise	0.8 (1)	0.7 to 0.9	1 (0.9)	0.9 to 1	<0.001
Malignancy	0.4 (1.2)	0.3 to 0.6	0.8 (1.1)	0.8 to 0.9	<0.001
End-stage status	−0.7 (1.1)	(−0.9) to (−0.6)	−0.4 (1.1)	(−0.4) to (−0.3)	<0.001
Obesity	0.2 (0.7)	0.1 to 0.3	0.2 (0.6)	0.2 to 0.2	N/S

**Not significant.*

of participants considered patients of other nationalities to have equal priority as Iranians. Iran is host to millions of refugees from neighboring countries, mostly Afghanistan. Given the vulnerable state of refugees in terms of health and care-seeking behavior (21), policies need to be directed to avoid the stigmatization against refugees in resource allocation. Ventilators should not be allocated based on morally irrelevant aspects. In this sense, all stakeholders need to bear in mind that the principles of accessibility, dignity, and equal opportunities need to be considered in allocating scarce resources.

Participants acknowledged the consideration of the patients' instrumental value. They assigned higher scores to physicians and nurses treating COVID-19 patients, as well as high-profile researchers. Those supporting the role of instrumental value argue that the prioritization of access to the resources for patients with essential skills to save others' lives could potentially multiply the net benefit to society (12, 22). Participants also assigned higher scores to pregnant mothers or those who had children under 2 years old. Some triage models consider having someone dependent on care as a criterion to lessen the harm caused to families and society (12).

Participants would prioritize patients with underlying diseases to access ventilators. Moreover, they would equally allocate ventilators to patients with end-stage status. On the contrary, healthcare workers assigned very low scores to patients with end-stage status. This calls for more effective communication and knowledge translation by public health authorities and the media to regularly convey the prognostic factors of COVID-19 based on emerging evidence to justify people's expectations from the healthcare systems. The disruption of the resource supply imposed by the COVID-19 pandemic has challenged the public's shared belief that healthcare services are provided whenever requested. Thus, people need to beware of the catastrophic aftermaths of not abiding by preventive protocols (23, 24). To

date, global organizations have proposed no unique criteria for the fair allocation of mechanical ventilators. Such protocols need to be developed and implemented regarding each country's local context or state (25). As the COVID-19 pandemic is a rapidly evolving crisis, it is of paramount importance to regularly reevaluate current practices based on the emerging evidence and feedback of all stakeholders, including public health authorities, decision-makers, clinicians the general public.

STRENGTHS AND LIMITATIONS

This is among the few studies to assess the public opinions on priorities toward fair allocation of mechanical ventilators during the COVID-19 pandemic. Findings could empower public health authorities better to understand people's views on the matter as stakeholders to avoid public distrust and improve people's compliance to health-promoting measures. Nevertheless, the study does not overshadow the need for accelerated production and enhanced distribution of ventilators (26). Operational management aspects of allocating ventilators also need to be taken into account at all levels to enhance prompt response to the devastating demands as imposed by the COVID-19 pandemic (27).

Some limitations must be acknowledged. The study was conducted via Google Forms, an online survey platform because there was no representative online platform for rapid surveys among people in Iran. While the study could be subject to selection bias, its rapid conduction via an online platform could outweigh its limitation. Compared to Iran's most recent national population statistics, our sample was over-representative of women and health workers. Considering that healthcare workers also comprise most of the authorities of the healthcare system in Iran, their opinions were compared with the public to gain a deeper understanding of the potential differences in their points of view. Although the Internet penetration rate in Iran is high, the elderly and vulnerable groups in rural areas might not have access to the platform, who might have gotten underrepresented in the study. Participants were asked to read the questionnaire to their parents and grandparents to ensure higher participation of those groups; however, such voluntary measures are not guaranteed. Some 99.6% of Iranians are Muslims (28), thus religion had no bearing on the choice of allocation in this study.

CONCLUSION

Participants stated that socioeconomic factors, except for age>80, should not be involved in prioritizing mechanical ventilators at the time of resources scarcity. Front-line physicians and nurses of COVID-19 patients, pregnant mothers, mothers who had children under 2 years old were given high priority.

DATA AVAILABILITY STATEMENT

The raw data supporting the conclusions of this article will be made available by the authors, without undue reservation.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Ethical Committee of Shahid Beheshti University of Medical Sciences, Tehran, Iran under code IR.SBMU.RETECH.REC.1399.167. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

A-AK and MA-K: conceptualization and writing—review and editing. A-AK, MA-K, SA, and HH-M: data collection. MA-K: data analysis. MA-K, SA, and HH-M: writing—original draft. A-AK: resources and supervision. All authors have read and approved the manuscript prior to submission.

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REFERENCES

1. Emanuel EJ, Persad G, Upshur R, Thome B, Parker M, Glickman A, et al. Fair allocation of scarce medical resources in the time of Covid-19. *N Engl J Med.* (2020) 382:2049–55. doi: 10.1056/NEJMsb2005114
2. Wu HL, Huang J, Zhang CJP, He Z, Ming WK. Facemask shortage and the novel coronavirus disease (COVID-19) outbreak: reflections on public health measures. *EClinicalMedicine.* (2020) 21:100329. doi: 10.1016/j.eclinm.2020.100329
3. Truog RD, Mitchell C, Daley GQ. The toughest triage — Allocating ventilators in a pandemic. *N Engl J Med.* (2020) 382:1973–5. doi: 10.1056/NEJMp2005689
4. Ing EB, Xu QA, Salimi A, Torun N. Physician deaths from corona virus (COVID-19) disease. *Occup Med.* (2020) 70:370–4. doi: 10.1093/occmed/kqaa088
5. Adeniji KA, Cusack R. The Simple Triage Scoring System (STSS) successfully predicts mortality and critical care resource utilization in H1N1 pandemic flu: a retrospective analysis. *Crit Care.* (2011) 15:R39. doi: 10.1186/cc10001
6. Christian MD, Hawryluck L, Wax RS, Cook T, Lazar NM, Herridge MS, et al. Development of a triage protocol for critical care during an influenza pandemic. *CMAJ.* (2006) 175:1377–81. doi: 10.1503/cmaj.060911
7. Challen K, Bentley A, Bright J, Walter D. Clinical review: mass casualty triage - pandemic influenza and critical care. *Crit Care.* (2007) 11:212. doi: 10.1186/cc5732
8. The Lancet. COVID-19: protecting healthcare workers. *Lancet.* (2020) 395:922. doi: 10.1016/S0140-6736(20)30644-9
9. Swiss Academy Of Medical Sciences. COVID-19 pandemic: triage for intensive-care treatment under resource scarcity. *Swiss Med Wkly.* (2020) 150:w20229. doi: 10.4414/smw.2020.20229

10. Huseynov S, Palma MA, Nayga RM. General public preferences for allocating scarce medical resources during COVID-19. *Front Public Health.* (2020) 8:587423. doi: 10.3389/fpubh.2020.587423
11. Buckwalter W, Peterson A. Public attitudes toward allocating scarce resources in the COVID-19 pandemic. *PLoS ONE.* (2020) 15:e0240651. doi: 10.1371/journal.pone.0240651
12. Frolic A, Kata A, Kraus P. Development of a critical care triage protocol for pandemic influenza: integrating ethics, evidence and effectiveness. *Healthc Q.* (2009) 12:54–62. doi: 10.12927/hcq.2009.21054
13. Daugherty Biddison EL, Faden R, Gwon HS, Mareiniss DP, Regenberg AC, Schoch-Spana M, et al. Too many patients…A framework to guide statewide allocation of scarce mechanical ventilation during disasters. *Chest.* (2019) 155:848–54. doi: 10.1016/j.chest.2018.09.025
14. Brown TR, Francis LP, Tabery J. Embedding the problems doesn't make them go away. *Am J Bioeth.* (2020) 20:109–11. doi: 10.1080/15265161.2020.1779864
15. Gupta S, Hayek SS, Wang W, Chan L, Mathews KS, Melamed ML, et al. Factors associated with death in critically ill patients with Coronavirus disease 2019 in the US. *JAMA Intern Med.* (2020) 180:1436–46. doi: 10.1001/jamainternmed.2020.3596
16. Yang X, Yu Y, Xu J, Shu H, Xia J, Liu H, et al. Clinical course and outcomes of critically ill patients with SARS-CoV-2 pneumonia in Wuhan, China: a single-centered, retrospective, observational study. *Lancet Respir Med.* (2020) 8:475–81. doi: 10.1016/S2213-2600(20)30079-5
17. Rezaei N, Montazeri F, Malekpour M-R, Ghanbari A, Azadnajafabad S, Mohammadi E, et al. COVID-19 in patients with diabetes: factors associated with worse outcomes. *J Diabetes Metab Disord*. (2021) 20:1605–14. doi: 10.1007/S40200-021-00910-3
18. Sprung CL, Joynt GM, Christian MD, Truog RD, Rello J, Nates JL. Adult ICU triage during the Coronavirus disease 2019 pandemic: who will live and who will die? Recommendations to improve survival. *Crit Care Med.* (2020) 48:1196–202. doi: 10.1097/CCM.0000000000004410
19. Haas LEM, de Lange DW, van Dijk D, van Delden JJM. Should we deny ICU admission to the elderly? Ethical considerations in times of COVID-19. *Crit Care.* (2020) 24:321. doi: 10.1186/s13054-020-03050-x
20. Auriemma CL, Molinero AM, Houtrow AJ, Persad G, White DB, Halpern SD. Eliminating categorical exclusion criteria in crisis standards of care frameworks. *Am J Bioeth.* (2020) 20:28–36. doi: 10.1080/15265161.2020.1764141
21. Abbasi-Kangevari M, Amin K, Kolahi AA. Antenatal care utilisation among Syrian refugees in Tehran: a respondent driven sampling method. *Women Birth.* (2020) 33:e117–e121. doi: 10.1016/j.wombi.2019.02.001
22. Sztajnkrycer MD, Madsen BE, Alejandro Báez A. Unstable ethical plateaus and disaster triage. *Emerg Med Clin North Am.* (2006) 24:749–68. doi: 10.1016/j.emc.2006.05.016
23. Abbasi-Kangevari M, Kolahi AA, Ghamari SH, Hassanian-Moghaddam H. Public knowledge, attitudes, and practices related to COVID-19 in Iran: Questionnaire study. *JMIR Public Heal Surveill.* (2021) 7:e21415. doi: 10.2196/21415
24. Hatami H, Abbasi-Kangevari M, Malekpour MR, Kolahi AA. Knowledge, attitudes, and safety practices about COVID-19 among high school students in iran during the first wave of the pandemic. *Front Public Health.* (2021) 9:680514. doi: 10.3389/FPUBH.2021.680514
25. Dos Santos MJ, Martins MS, Santana FLP, Furtado MCSPC, Miname FCBR, Pimentel RRDS, et al. COVID-19: instruments for the allocation of mechanical ventilators- A narrative review. *Crit Care.* (2020) 24:582. doi: 10.1186/s13054-020-03298-3
26. Rafigh P, Akbari AA, Bidhandi HM, Kashan AH. Sustainable closed-loop supply chain network under uncertainty: a response to the COVID-19 pandemic. *Environ Sci Pollut Res Int.* (2021). 1–17. doi: 10.1007/s11356-021-16077-6
27. Mehrotra S, Rahimian H, Barah M, Luo F, Schantz K. A model of supply-chain decisions for resource sharing with an application to ventilator allocation to combat COVID-19. *Nav Res Logist.* (2020) 67:303–20. doi: 10.1002/nav.21905
28. Statistical Center of Iran > Population and Housing Censuses. Available online at: https://www.amar.org.ir/english/Population-and-Housing-Censuses (accessed: September 10, 2021).

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COVID-19 Pandemic Preparedness in Egypt's Teaching Hospitals: A Needs Assessment Study

Muhammad Mostafa Abd El Ghaffar[1], Marwa Rashad Salem[2], Mohamed Fawzy Al Soda[3], Madiha Said Abd El Razik[2], MarwAli Hassab Tahoon[4], Mohamed Fathy Tahoon[5], Basem Eysa[6], Abd Elfattah Elsayed Hegazy[7], Abdelkarem Emam Eleraky[8], Ayman A. Eltayar[9], Wael Mahmoud Hossam El Din Eldarandly[10] and Dalia Omran[11]*

[1] Department of Gastroenterology and Infectious Diseases, Ahmed Maher Teaching Hospital, Cairo, Egypt, [2] Department of Public Health and Community Medicine, Public Health and Community Medicine, Faculty of Medicine, Cairo University, Cairo, Egypt, [3] General Organization for Teaching Hospitals and Institutes, Cairo, Egypt, [4] National Liver Institute, Menoufia University, Shebeen El-Kom, Egypt, [5] General Surgery Department, Shebin Elkom Teaching Hospital, Shebin El-Kom, Egypt, [6] Gastroenterology Department, National Hepatology and Tropical Medicine Research Institute, Cairo, Egypt, [7] General Surgery Department, Elsahel Teaching Hospital, Cairo, Egypt, [8] Orthopedic Surgery Department, Al Ahrar Teaching Hospital, Zagazig, Egypt, [9] Intensive Care Department, Damanhour Teaching Hospital, Damanhour, Egypt, [10] Anaesthesia Department, Matarya Teaching Hospital, Cairo, Egypt, [11] Faculty of Medicine, Endemic Medicine Department, Cairo University, Cairo, Egypt

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Edited by:
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Suez Canal University, Egypt

***Correspondence:**
Marwa Rashad Salem
mr80002000@kasralainy.edu.eg

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Introduction: Regular collection and monitoring of data describing the dynamics of the utilization of healthcare services, especially in teaching hospitals (TH), which provide model quality medical services, are critical for COVID-19 pandemic preparedness.

Methods: The researchers analyzed data and information derived from service statistics reports from June 1st to July 15th, 2020 in terms of hospital resources, as well as utilization patterns of beds, ICU, and ventilators, for 11 screening hospitals affiliated with the General Organization of Teaching Hospitals and institutes in Egypt assigned by the Ministry of Health and Population to provide medical care for COVID-19 patients. Hospital indicators in terms of COVID-19 screening services, as well as utilization patterns of inpatient beds, ICU beds, and ventilators were computed.

Results: A total of 78,869 non-medical personnel and 2,176 medical personnel were presented with COVID-19 triage symptoms. Investigations conducted in the targeted 11 hospitals delineated that 22.2% of non-medical personnel and 27.9% of medical personnel were COVID-19 PCR-confirmed cases. The inpatient bed occupancy rate was 70% for non-medical patients and 67% for medical staff patients. For ICU, the bed occupancy rate was 92 % for non-medical patients and 88% for medical patients. Among the confirmed cases, 38% of medical patients utilized a ventilator vs. 36% of medical personnel cases. Hospital ranking according to utilization pattern among non-medical personnel, Hospital H ranked first in terms of the high load of screening services. Hospital C ranked first regarding the number of confirmed cases, whereas Hospital D ranked first for high ICU utilization among all teaching hospital ICU cases. With respect to medical personnel, Hospital G ranked first for the high load of screening services for the total studied cases. Hospital G ranked first for the number of confirmed cases. Hospital B ranked first regarding high ICU utilization among all teaching hospital ICU cases.

Conclusion: Teaching hospitals have demonstrated preparedness for the COVID-19 pandemic by maintaining an inpatient bed occupancy rate of 70% or less and ventilator utilization at <40% of confirmed cases. However, the ICU bed occupancy rate was more than 90% indicating a shortage of resources. In addition, there is variance across hospitals regarding caseload for resource reallocation decisions.

Keywords: COVID-19, ICU, Egypt, service statistics, teaching hospitals

INTRODUCTION

As the world responds to the emerging COVID-19 pandemic, the change in current global public health priorities is revealing crucial weaknesses in global health systems (1). Worldwide, there are growing concerns about the need for hospital beds that will overwhelm national capacity, placing severe strains on the health care system and limiting access to essential care (2). A decrease in the number of hospital beds, intensive care beds, and ventilators representing weaknesses in healthcare systems worldwide has been reported (3, 4). Critical care capacity in low- and middle-income countries (LMICs) was inadequate prior to the pandemic, and they are at risk of not being able to cope with the estimated rise in critically ill COVID-19 patients, with current estimates of 0.1–2.5 ICU beds per 100,000 people are open (3). However, shortages have spread to even more resourced health systems around the world (5). Since healthcare systems (mainly hospitals) are the first line of defense to face this pandemic, the COVID-19 negative effects imposed exceptional challenges to these systems and posed a direct threat to their workers (6), especially in developing countries like Egypt, which suffered from a lack of resources and a weak health system prior to the pandemic (7).

The Egyptian government abandoned individual hospitals in every governorate to be assigned as quarantine hospitals for COVID-19 patients (Isolation Hospitals) after the first outbreak of COVID-19 in Egypt on February 14 (8), but infections continued to rise as the number of confirmed cases in Egypt increased. These statistics put additional pressure on the already overburdened public health sector, which has already received the majority of the cases and is overstretched (9).

As a result, regular collection and review of various data, such as healthcare capacity and usage, is critical for informing COVID-19 pandemic preparedness and response and organizational decision-making on service delivery (10). In the current study, the researchers attempted to investigate the situation in some of the COVID-19 screening hospitals in terms of inpatient beds, ICU beds, and ventilator utilization rates. Traditionally, the previously mentioned indicators were to provide policymakers with feedback on the COVID-19 response and to be used by decision-makers. We documented the number of hospitalized patients, either medical or non-medical personnel, with COVID-19 as a vital pulse on the severity of the disease in our community.

MATERIALS AND METHODS

A statistical report was written utilizing service statistics from 11 screening hospitals of the General Organization of Teaching Hospitals and Institutes (GOTHI) in Egypt. The Ministry of Health and Population (MOHP) assigned the screening hospitals of GOTHI to provide medical care for patients with COVID-19 infection in Egypt. All adult patients (≥18 years), including health care providers, who attended the studied Teaching Hospitals and Institutes with COVID-triage symptoms during the period from June 1 to July 15, 2020, whether or not they were admitted to the (GOTHI), were included in the current study. This range of dates falls within the first wave of the pandemic. We extracted data, including the numbers of confirmed cases, discharges, new deaths, and severe cases, during the study duration. There is no sampling at all, as all Eleven teaching hospitals in Egypt were included in the study, and all COVID-19 cases were attended to at teaching hospitals during a specific period of time.

Operational definitions of variables, terms, and indicators (11).

We computed the following indicators according to the following formulas:

1. Inpatient bed occupancy rate =
   $$\frac{\text{Total number of inpatient days for a given period} \times 100}{\text{Available beds} \times \text{Number of days in the period}}$$
2. ICU bed occupancy rate =
   $$\frac{\text{Total number of ICU days for a given period} \times 100}{\text{Available ICU beds} \times \text{Number of days in the period}}$$
3. Ventilator utilization rate = percent of patients with confirmed cases who used the ventilator.
4. In-hospital mortality rate for COVID-19 cases.

Percentage of hospital deaths of confirmed COVID-19 cases after 48 hours of admission during the specified time period to the total number of COVID-19 confirmed cases admitted to the hospital in the same specified time period.

COVID-19 CASE DEFINITIONS

The Egyptian Ministry of Health published a comprehensive guide for diagnosing and treating COVID-19. Patients with the COVID-19 infection are divided into mild, moderate, and severe cases (8).

Mild COVID-19 Cases

Symptomatic case with lymphopenia or leucopenia with no radiological signs for pneumonia.

Moderate COVID-19 Cases

The patient presents with pneumonia manifestations on radiology associated with symptoms and/or leucopenia or lymphopenia.

Severe COVID-19 Cases

If any of the following criteria are present:

1. RR > 30
2. SaO_2 < 92 at room air
3. PaO_2/FiO_2 ratio < 300
4. Chest radiology shows more than 50% lesion or progressive lesion within 24–48 h.
5. Critically ill if SaO_2 < 92, or RR > 30, or PaO_2/FiO_2 ratio < 200 despite oxygen therapy (12).

Table A | Setting Code for each of the studied teaching hospital.

No.	Hospital code
1	A
2	B
3	C
4	D
5	E
6	F
7	G
8	H
9	I
10	J
11	K

Statistical Analysis

Pre-coded data were entered and analyzed using Excel 2010 manufactured by Microsoft. Categorical variables were expressed in frequency and percentages. All the teaching hospitals and institutes were coded in letters A, B up to K for easy manipulation of data as displayed in **Table A**.

Ethical Approval

The Ethical Review Committee of the General Organization of Teaching Hospitals and Institutes (GOTHI) in Egypt revised and approved the study protocol.

RESULTS

Table 1 illustrated these 11 teaching hospitals that provided screening tests for ∼78,869 non-medical personnel who attended the hospital with COVID-triage symptoms during the period (June the 1st to July the 15th, 2020). Among the screened suspected non medical cases, 22% were confirmed as clinical cases of COVID-19. Among the confirmed cases, 72.2% were mild and 23.2% were moderate and severe cases. Out of the confirmed cases, 4.6 % were admitted to the ICU of the corresponding hospital.

The corresponding figures for Medical Staff cases were as follows: 10 teaching hospitals provided screening tests for about

TABLE 1 | The percentage of PCR confirmed COVID-19 cases among total suspected cases presented with COVID-19 symptoms to teaching hospitals (June 1st to July 15th, 2020).

Type of patients	No. of suspected cases presented with COVID triage symptoms	No (%) of confirmed cases	No (%) Confirmed cases (mild)	No (%) Confirmed cases (moderate and sever cases admitted inpatients)	No (%) Confirmed cases need ICU
Cases not including medical staff	78,869	17,508 (22.2%)	12,643 (72.2%)	4,063 (23.2%)	802 (4.6%)
Medical staff members	2,176	609 (27.9%)	418 (68.6%)	174 (28.6%)	17 (2.8%)

TABLE 2 | Inpatient bed occupancy and ICU bed occupancy and ventilator utilization rates for COVID-19 confirmed cases admitted to teaching hospitals (June 1 to July 15, 2020).

Type of patients	Inpatient bed occupancy rate	ICU bed occupancy rate	Ventilator utilization rate
Cases not including medical staff	70%	92%	38%
Medical staff members	67%	88%	36%

TABLE 3 | Percent of teaching hospital discharges for COVID-19 confirmed cases and in-hospital mortality rate throughout the period (June 1 to July 15, 2020).

Type of patients	Total number of confirmed cases	No (%) discharged cases	Total number of deaths	In hospital mortality rate
Cases not including medical staff	17,508	3,454 (20%)	1,290	7.3%
Medical staff	609	368 (60.4%)	18	2.9%

2,176 medical staff who attended the hospital with COVID-triage symptoms during the period (June the 1st to July the 15th, 2020). Among the screened cases, 27.9% were confirmed as clinical cases of COVID-19. Among the confirmed cases, 68% were mild and 28.6% were moderate and severe cases. Among the confirmed cases, 2.8% were admitted to the ICU in the corresponding hospital (**Table 1**).

Inpatient bed occupancy and ICU bed occupancy and ventilator utilization rates for COVID-19 confirmed non-medical and medical admitted to the teaching hospitals (June 1st to July 15th, 2020) are illustrated in **Table 2**. The bed occupancy rate for COVID-19 confirmed was 70% for non-medical cases, and it was 92% for ICU admissions. The percent of confirmed cases utilizing ventilators was 38%. Corresponding figures for medical staff member cases were 67% for in-patient cases, 88% for cases admitted to ICU. The percent of confirmed cases that utilized ventilators was 36%.

Table 3 showed that 20% were reported as discharged cases and deaths after 48 h of admission were 7.3% for the total cases of non medical personnel. Corresponding figures for medical staff member cases were 60.4%, discharged cases 2.9% deaths after 48 h.

Figure 1 illustrates the caseload per teaching hospital for screening tests for COVID-19 triage non-medical personnel. The percent contribution for a hospital in screening tests services showed the Hospital H ranked first, Hospital B ranked second, Hospital A ranked third, and Hospital E ranked last.

On the contrary, the distribution of PCR confirmed COVID-19 across 11 Teaching hospitals showed the Hospital C ranked first, Hospital B ranked second, and Hospital J ranked third for non-medical personnel as shown in **Figure 2**.

Figure 3 shows the percent distribution of PCR confirmed COVID-19 across 11 Teaching hospitals among non-medical cases who utilized ICU—Egypt: (June 1 to July 15, 2020). Hospital D ranked first, hospital B ranked second and C ranked third.

Figure 4 illustrates the caseload per teaching hospital for screening tests for COVID-19 triage medical cases. The percent contribution for a hospital in screening tests services showed that Hospital G ranked first, Hospital H ranked second, while Hospital C ranked third. Hospital J ranked last.

The percent distribution of PCR confirmed COVID-19 across 10 Teaching hospitals among medical personnel—Egypt is shown in **Figure 5**. Hospital G reported the highest percentage of confirmed cases, followed by hospital C, while Hospital I ranked last. **Figure 6** illustrates the percent distribution of PCR confirmed COVID-19 across 10 Teaching hospitals among medical cases who utilized ICU—Egypt: (June 1 to July 15, 2020). It is clear from the figure that hospital B ranked first followed by hospital F (**Figure 6**).

DISCUSSION

The current study presented a model for hospital care dynamics for COVID-19 patients in 11 teaching hospitals in Egypt from June 1 to July 15, 2020. The study focused on the patient cycle from the triage stage of the COVID-19 conduction of screening tests, hospital care, and discharge. Additionally, the study used specific output indicators to present utilization patterns for hospital resources as in-patient hospital bed occupancy and ICU bed occupancy, and percent of admitted cases utilized ventilators. The outcome indicator used in the study was the percent of discharged cases out of the total admitted hospital cases. The impact indicator used in the study was the in-hospital mortality rate. The indicators used to measure the dynamics of the patient cycle were determined on data derived from 11 hospitals during a specific period of COVID-19-Wave I. The indicators in the article were organized according to patient cycle steps. The caseload per teaching hospital for screening tests for COVID-19 triage for non-medical and medical staff cases could interpret hospital capacity to conduct screening tests. The percent contribution for a hospital in screening tests services showed that Hospital H ranked first, Hospital B ranked second, and Hospital ranked third. With regard to medical staff cases, Hospital G ranked first, Hospital H ranked second, and Hospital C ranked third. These hospitals have priority in providing resources for COVID-19 screening services to deal with the high caseload targeting screening.

In contrast, for medical staff cases; Hospital G has priority for providing in-patient (hospital beds) services resources to maintain a low bed occupancy to respond to the high flow of confirmed cases.

The inpatient bed occupancy rate for COVID-19 confirmed cases has reached 70% for non-medical cases. The corresponding figure for medical staff cases was 67%. ICU bed occupancy rate for patients was more than 90%, which is an alarming signal of a shortage of resources. This was corresponding to the figure reported by the Minister of Health and Population in Egypt (84%) by COVID-19 patients (13). In the current study, variance across hospitals regarding ICU occupancy rate guides for resource reallocation decisions where a recent study conducted by Labib et al. (14) in Egypt to assess ICU preparedness during the COVID-19 pandemic revealed that the overall preparedness in both pediatric and adult ICUs was 54%. This situation could be due to the current belief that COVID-19 mainly affects adults with more severe cases than those observed among children.

Impact indicators and cases of COVID-19 in-hospital mortality among non-medical and medical staff cases indirectly reflect multiple independent variables as hospital services and characteristics of the patients as age, sex, and comorbidities.

The distribution and severity of COVID-19 are substantially dissimilar in different parts of the world. The in-hospital mortality rate of cases admitted to the ICU is between 23.4 and 33%. The mortality rate among patients receiving mechanical ventilation is 43 to 67% and is close to 70% among patients older than 60 years (15). In the current statistical report, from 17,508 patients without medical staff, 1,290 cases died (7.3%). An analysis of American Hospital Association data with COVID-19 data revealed an association between low hospital resources and mortality (16). On the contrary, given their daily interaction with infected patients, medical staffs are at risk of contracting COVID-19. The average incidence of COVID-19 infection among healthcare staff has been about 10%. In

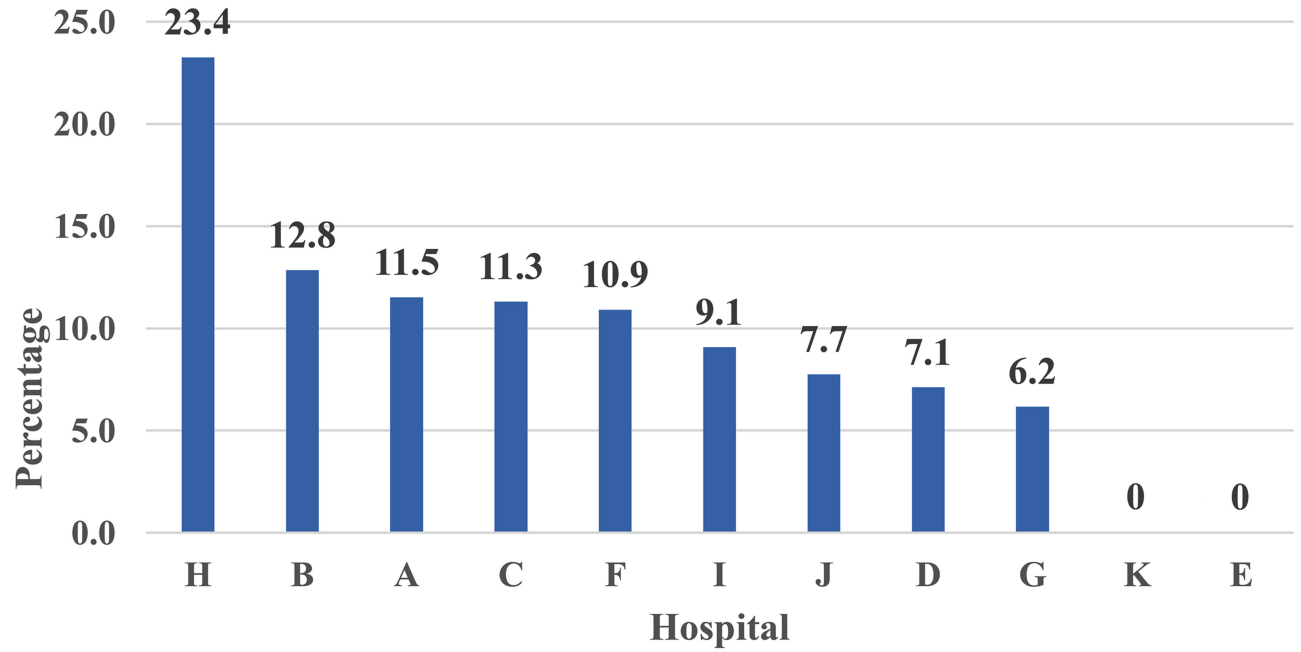

FIGURE 1 | Percent distribution of screened non-medical personnel with COVID-19 triage across 11 Teaching hospitals—Egypt: (June 1 to July 15, 2020)—Rank ordering.

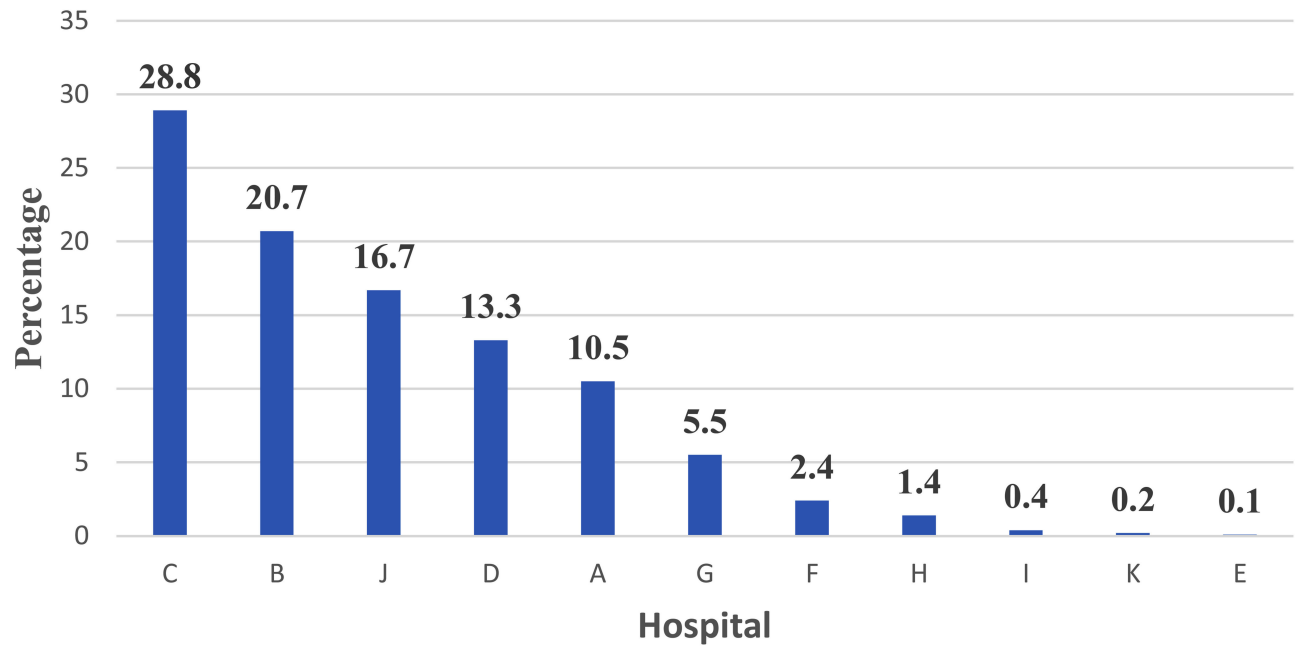

FIGURE 2 | Percent distribution of PCR confirmed COVID-19 across 11 Teaching hospitals among non-medical personnel—Egypt: (June 1 to July 15, 2020) —Rank ordering.

the United States, this percentage was 18%, while in China it was 4% and 9% in Italy (17). The availability of high-quality personal protective equipment (PPE) kits, proper use of PPE, and infection prevention training programs are all important factors in lowering infection rates. As revealed from the current study, a higher percentage of medical staff 27.9% were confirmed as clinical cases of COVID-19. This high percentage came according to the Egyptian government official reports, as the number of infected and deceased Egyptian doctors as well as allied health workers increased compared to the general

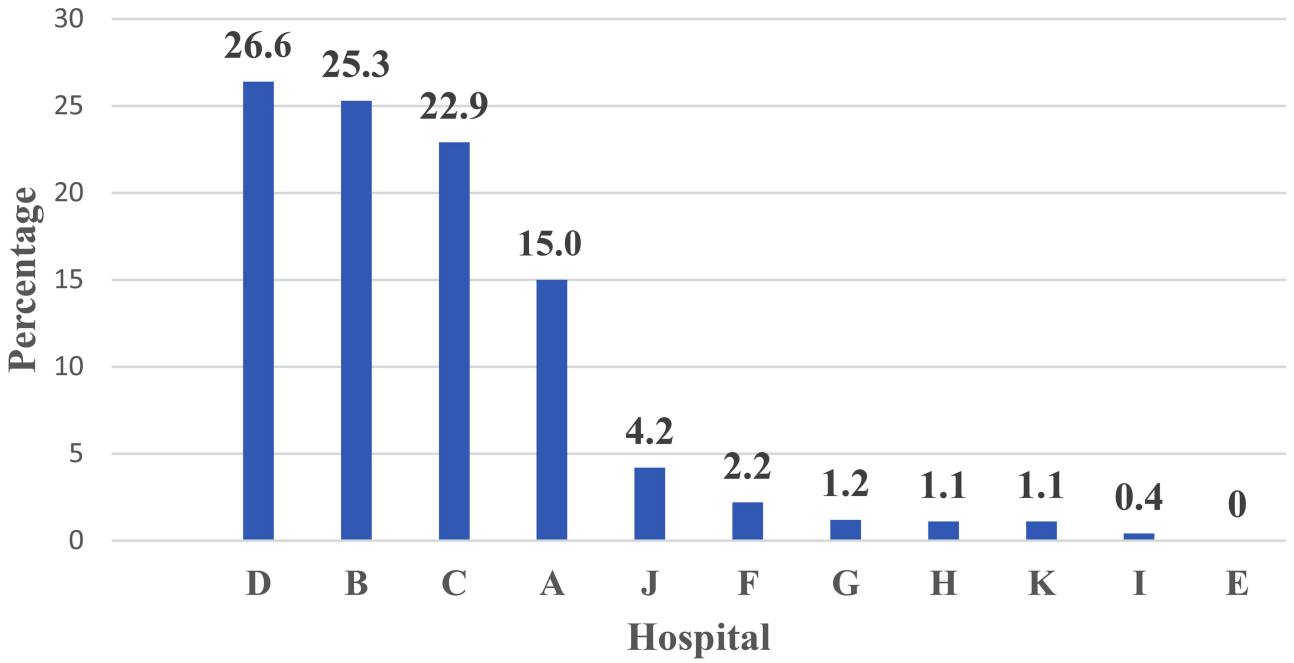

FIGURE 3 | Percent distribution of PCR confirmed COVID-19 across 11 Teaching hospitals among non-medical cases who utilized ICU—Egypt: (June 1 to July 15, 2020) —Rank ordering.

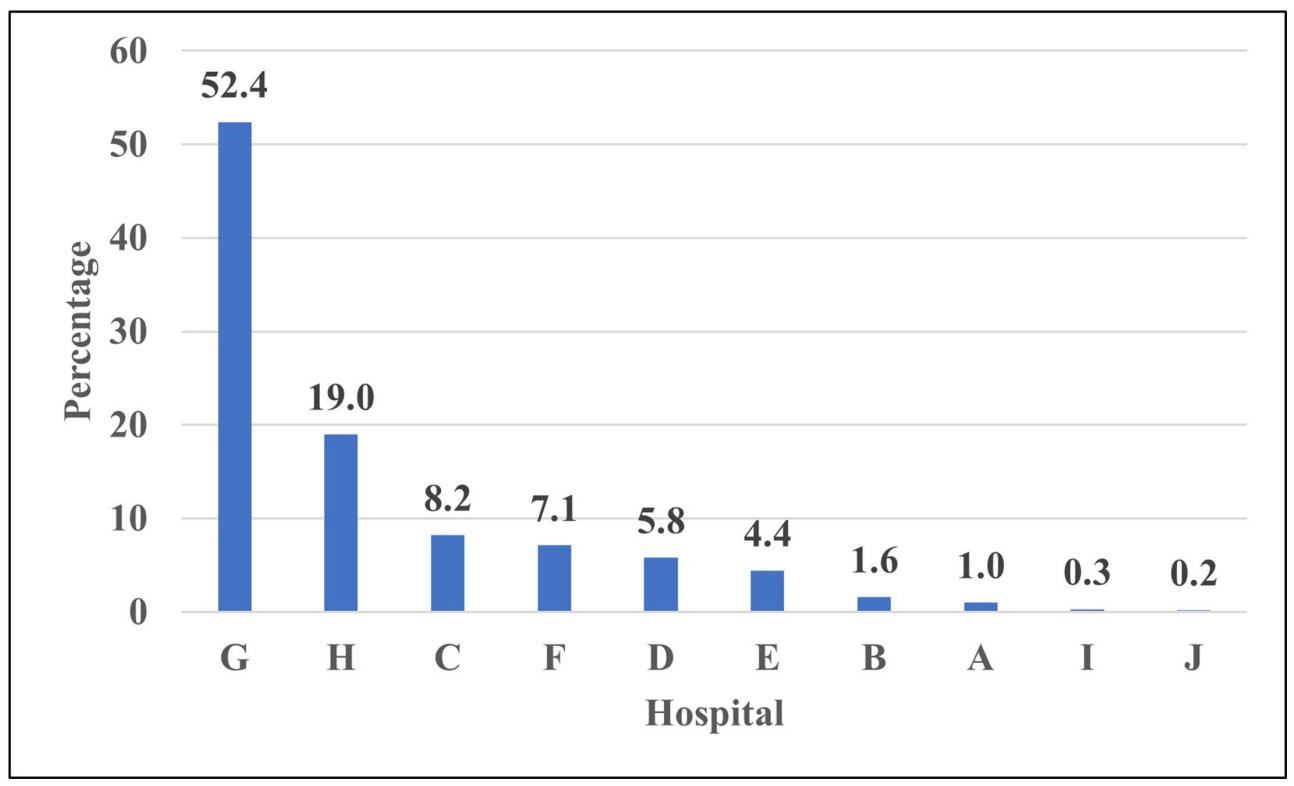

FIGURE 4 | Percent distribution of screened medical personnel with COVID-19 triage across 10 Teaching hospitals—Egypt: (June 1 to July 15, 2020) —Rank ordering.

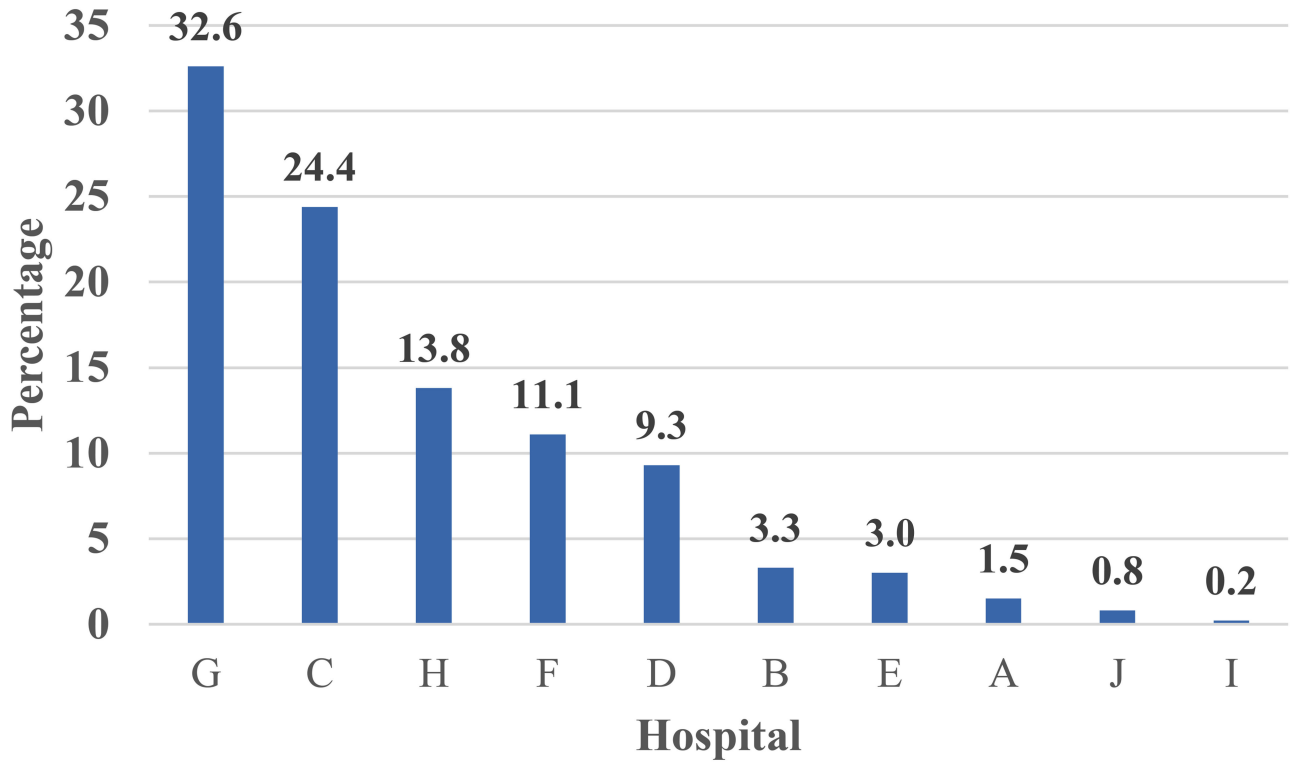

FIGURE 5 | Percent distribution of PCR confirmed COVID-19 across 10 Teaching hospitals among medical personnel—Egypt: (June 1 to July 15, 2020)—Rank ordering.

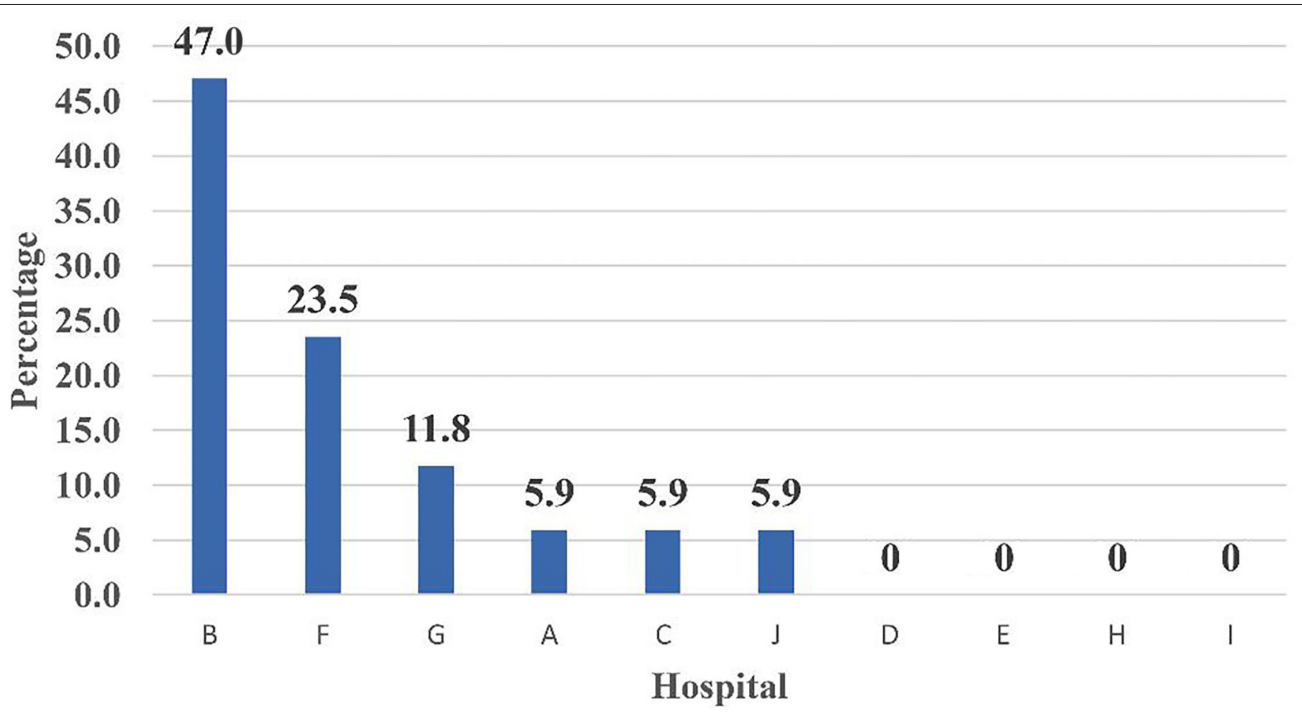

FIGURE 6 | Percent distribution of PCR confirmed COVID-19 across 10 Teaching hospitals among medical cases who utilized ICU—Egypt: (June 1 to July 15, 2020)—Rank ordering.

population. On the frontlines of protection against the COVID-19 pandemic protection, health care workers are exposed to not only COVID-19 infection due to their daily contact with infected individuals, but also psychological distress, long work hours, exhaustion, workplace stigma, and physical abuse. Policymakers in Egypt are acquainted with the high risk of exposure of the medical teams to COVID-19 infection. They adopted different strategies to reduce the risk of exposure of medical staff to COVID-19 infection. The Minister of Health and Population in Egypt has allocated a floor in each isolation hospital with a capacity of 20 beds, to treat infected medical staff, as part of the Ministry's efforts to protect its medical teams to confront them with the emerging Coronavirus, providing psychological, and administrative support. Additionally, infection control teams in hospitals are working daily to review the stock of preventive supplies, and to ensure that medical teams are following precautions to prevent any medical staff from being infected with the virus. The Egyptian Minister demonstrated that they distributed large quantities of preventive supplies to hospitals, besides conducting weekly webinars targeting all health care workers to keep them updated with COVID-19 management protocols and infection control measures (18). Despite the efforts of MOHP, the current study revealed high hospital mortality among medical staff. This needs further investigations into the reason behind the high in-hospital mortality rate among HCWs in Egypt.

The study focused on information derived from 11 teaching hospitals. Hospitals' presentation and contribution to providing specific services to COVID-19 cases were crucial for policy and decision-makers. The indicators indirectly reflect the demand side for teaching hospitals. The demand side is measured by the percent contribution of each hospital in providing screening tests to COVID-19 triage cases. This indicator delineated caseload at an outpatient level and was influenced by the catchment area of each hospital, and the level of acceptability of specific hospital services by the served community. The availability and quality of services contribute to the magnitude of such indicators. The supply side is related to the availability of qualified medical health human resources, screening Lab services, ICU, and ventilators. The interaction between demand and supply-side was measured by outcome and impact indicators as discharged cases and in-hospital mortality. To avoid overload and saturation, one of the primary problems was to manage health resources quickly and efficiently. This is especially relevant in nations where there was a dearth of accessible beds (which filled quickly in the early days of epidemics), as well as a shortage of health professionals (who were overworked) (19, 20).

CONCLUSION

Teaching hospitals have demonstrated preparedness for the COVID-19 pandemic by keeping the bed occupancy rate at 70% or less and ventilator utilization at <40% of confirmed cases. However, the bed occupancy rate in ICU was more than 90% indicating a shortage of resources for critical clinical cases of COVID-19 cases. Impact indicators as in-hospital mortality among non-medical and medical staff cases indirectly reflect multiple independent variables as hospital services and patient characteristics such as age, sex, and comorbidities.

CLINICAL IMPLICATIONS

In clinical areas, the findings of this study can help hospital administrators and hospital leaders to identify the strengths and weaknesses of hospital preparedness for suspected and confirmed cases of COVID-19. The hospital can be guided in designing a continuing education program that would enhance hospital preparedness. Identifying the strained aspects of hospital preparedness is crucial to improving and strengthening their work in the prevention, control, management, and containment of the COVID-19 pandemic.

RECOMMENDATIONS

- Hospitals that have priority in providing lab resources for screening tests were Hospitals H, B, and G. Facilities are needed to manage clinically confirmed cases of Hospitals G, C, and H.
- Hospitals that have priority in providing in-patient (hospital beds) services resources for maintaining low bed occupancy to respond to a high flow of confirmed cases were Hospitals C, B, and J.
- Hospitals that have priority in providing in-patient (ICU) services resources for keeping response to critical cases were hospital D followed by hospital B and C.

STRENGTHS

- The study was conducted during the pandemic and concerned with the supply side of hospitals to control comorbidities and deaths.
- The information included both medical and non-medical groups regarding diagnostic tests, ICU utilization, and the use of ventilators.
- The study could measure the preparedness of hospitals during the pandemic, which is an important issue to be considered in health care.
- It is a policy-oriented research as it has its implications for policymakers at hospitals and MOHP-Headquarter.
- The study included different departments of the Ministry of Health: surveillance of COVID-19, curative care sector, logistic managements (keeping a good number of ventilators), and pharmaceutical sector to supply medications according to the flow of cases.
- The study has specific implications for the medical syndicate, as the study displayed information about medical staff.
- The study demonstrated different indicators to be used for monitoring and evaluating the performance of hospitals during pandemics.
- Future studies in the hospitals may be conducted to monitor the changes over time.

LIMITATIONS OF THE STUDY

The current study findings should be viewed with respect to the following limitations. First, the data were derived from the hospitals during the pandemic. Therefore, there are a limited number of variables that may contribute to the analysis and the development of more indicators. No information is available for the characteristics of patients such as age, sex, comorbidity to justify the use of hospital beds, ICU, and ventilators as well as in-hospital mortality. Further assessment during different phases of the COVID-19 pandemic is required. Second, the results cannot be generalized as it is not an epidemiological study, since it is operation research, health services management-oriented study only the methodology can be generalized and to be replicated in other medical settings.

DATA AVAILABILITY STATEMENT

The original contributions presented in the study are included in the article/supplementary material, further inquiries can be directed to the corresponding author/s.

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Teaching Hospitals-Egypt. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

AUTHOR CONTRIBUTIONS

MuA conceived the study, contributed to managing the literature searches, and data management. MS assisted with the literature search and writing. MaA contributed to data analysis and results writing. DO and MoA contributed to data collection and writing. MaT, MoT, BE, AH, AbE, WE, and AyE shared in data collection, drafting, and approving the final manuscript in the study. All authors contributed to the article and approved the submitted version.

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REFERENCES

1. Weissman GE, Crane-Droesch A, Chivers C, Luong T, Hanish A, Levy MZ, et al. Locally informed simulation to predict hospital capacity needs during the COVID-19 pandemic. *Ann Intern Med*. (2020) 173:21–8. doi: 10.7326/M20-1260
2. Turner HC, Hao NV, Yacoub S. Achieving affordable critical care in low-income and middle-income countries. *BMJ Glob Health*. (2019) 4:e001675. doi: 10.1136/bmjgh-2019-001675
3. The World Bank World Bank Country and Lending Groups (2020). Available online at: https://datahelpdesk.worldbank.org/knowledgebase/articles/906519-world-bank-country-and-lending-groups (accessed March 30, 2020).
4. Dong E, Du H, Gardner L. An interactive web-based dashboard to track COVID-19 in real-time. *Lancet Infect Dis*. (2020) 20:P533–534. doi: 10.1016/S1473-3099(20)30120-1
5. White DB, Lo B. A framework for rationing ventilators and critical care beds during the COVID-19 pandemic. *JAMA*. (2020) 323:1773–4. doi: 10.1001/jama.2020.5046
6. Ma X, Vervoort D. Critical care capacity during the COVID-19 pandemic: global availability of intensive care beds. *J Crit Care*. (2020) 58:96–7. doi: 10.1016/j.jcrc.2020.04.012
7. OECD. *OECD Policy Responses to Coronavirus (COVID-19): COVID-19 Crisis Response in MENA Countries*. Paris: Organisation for Economic Co-operation and Development (2020). Available Online at: https://www.oecd.org/coronavirus/policy-responses/covid-19-crisis-response-in-mena-countries-4b366396/ (accessed November 6, 2020).
8. Medhat MA, El Kassas M. COVID-19 in Egypt: Uncovered figures or a different situation? *J Glob Health*. (2020) 10:010368. doi: 10.7189/jogh.10.010368
9. Available Onlineat: https://www.healthresearchweb.org/en/egypt/institution_54 (accessed September 14, 2020).
10. Pecoraro F, Luzi D, Cesarelli M, Clemente F. A methodology of healthcare quality measurement: a case study. *J Phys Conf Ser*. (2015) 588:012027. doi: 10.1088/1742-6596/588/1/012027
11. Koch G. *Basic Allied Health Statistics And Analysis With Chapter by Frank Waterstraat*, 2nd ed (1999). Available online at: http://www.academia.dk/BiologiskAntropologi/Epidemiologi/PDF/Basic_Allied_Health_Statistics_and_Analysis.pdf
12. Masoud H, Elassal G, Hassany M, Shawky A, Hakim M, Zaky S, et al. *Management Protocol for COVID-19 Patients (Diagnosis and Treatment) MoHP Protocol for COVID19. Version 1.3* Egypt: Ministry of health and population (MOHP) (2020).
13. Lapolla P, Mingoli A, Lee R. Deaths from COVID-19 in healthcare workers in Italy—what can we learn? *Infect Control Hosp Epidemiol*. (2021) 42:364–5. doi: 10.1017/ice.2020.241
14. Labib JR, Kamal S, Salem MR, El Desouky ED, Mahmoud AT. Hospital preparedness for critical care during COVID-19 pandemic: exploratory cross-sectional study. *Open Access Maced J Med Sci*. (2020) 8:429–32. doi: 10.3889/oamjms.2020.5466
15. Janke AT, Mei H, Rothenberg C, Becher RD, Lin Z, Venkatesh AK. Analysis of hospital resource availability and COVID-19 mortality across the United States. *J Hosp Med*. (2021) 16:211–4. doi: 10.12788/jhm.3539
16. Balay-odao EM, Alquwez N, Inocian EP, Alotaibi RS. Hospital preparedness, resilience, and psychological burden among clinical nurses in addressing the COVID-19 crisis in Riyadh, Saudi Arabia. *Front Public Health*. (2021) 8:573932. doi: 10.3389/fpubh.2020.573932
17. Morgantini LA, Naha U, Wang H, Francavilla S, Acar Ö, Flores JM, et al. Factors contributing to healthcare professional burnout during the COVID-19 pandemic: a rapid turnaround global survey. *PLoS ONE*. (2020) 15:e0238217. doi: 10.1371/journal.pone.0238217
18. Available online at: https://www.care.gov.eg/EgyptCare/index.aspx (accessed April 10, 2021).
19. Pecoraro F, Luzi D, Clemente F. Analysis of the different approaches adopted in the Italian regions to care for patients affected by COVID-

19. *Int J Environ Res Public Health.* (2021) 18:848. doi: 10.3390/ijerph18030848
20. Griffin KM, Karas MG, Ivascu NS, Lief L. Hospital preparedness for COVID-19: a practical guide from a critical care perspective. *Am J Respir Crit Care Med.* (2020) 201:1337–44. doi: 10.1164/rccm.202004-1037CP

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