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COVID-19 pandemic and the social determinants of health

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COVID-19 pandemic and the social determinants of health

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Editorial: COVID-19 pandemic and the social determinants of health

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As we learn to co-exist with COVID-19, this Research Topic highlights significant research contributions that examine the interaction of COVID-19 and the social determinants of health. To emphasize the impactful research in this area, this Research Topic features scholarly contributions in the fields of Epidemiology, specifically Aging and Life-course Epidemiology, and Public Health, specifically Public Health Policy. This theme is intentionally broad in scope, and our editorial provides an overview of the key findings of the papers published in the Research Topic on COVID-19 pandemic and the social determinants of health. The types of articles received in response to this Research Topic are summarized below.

KEYWORDS

COVID-19, social determinants of health, disparity, marginalized populations, healthcare systems, health policy

Editorial on the Research Topic
COVID-19 pandemic and the social determinants of health

1 Original research

The COVID-19 pandemic shattered the illusion of an equitable society, starkly revealing how it has deepened the gaps created by pre-existing disparities in health and socio-economic conditions across the globe. The pandemic acted as a harsh spotlight, intensifying long-existing disparities and inequities, often hidden in plain sight. Marginalized communities, particularly racial and ethnic minorities, those living in poverty, individuals with lower educational and income attainments, and those reliant on hourly wages, have been disproportionately devastated by the pandemic (1–5). This situation is a glaring reminder of the deep-rooted inequities that have been normalized or overlooked in many societies for far too long.

Syndemic research provides a vital framework for understanding the intricate and intertwined nature of socio-cultural, socio-economic, structural, and individual factors and their integrated impact on disease prevalence (6). This approach is crucial for comprehending how these determinants interact with infectious diseases like COVID-19, societal epidemics, and confinement in certain social groups. The interaction of these factors can significantly exacerbate health disparities, leading to

poorer health outcomes, particularly in marginalized communities. The COVID-19 pandemic underscored the need for a comprehensive approach to public health crises that addresses these underlying social determinants of health to effectively combat and prevent future public health emergencies.

Petrelli et al. examined the difference in the incidence of intensive care (ICU), non-intensive care unit (non-ICU) hospital admissions, and mortality due to COVID-19 in the "inner areas" and metropolitan areas of Italy. The authors used a retrospective population-based study and observed a protective effect with respect to non-ICU admissions in "inner areas." ICU admissions and mortality were also lower in these areas in the early phases of the pandemic. This protection eventually disappeared, and a slight excess risk of ICU incidence and mortality occurred during the Omicron phase of the COVID-19 pandemic. The authors proposed that the more widespread vaccination coverage in metropolitan areas may explain this observation. The authors recommended that strengthening the primary prevention policies in the surrounding Italian areas may contribute to equity in health policies.

Yin et al. examined the social factors of the COVID-19 pandemic and its evolution in Hubei, China. The authors observed regional effects of the virus based on population density, distance from the seafood market in Wuhan, China, and sufficient medical supplies. Related research conducted by Xu et al. examined the impact of COVID-19 on health services utilization in China in 2020. The authors noted a decrease in outpatient health services during this time and the reasons for this observation were multifaceted. The authors recommended that access to health services, especially emergency care, should be increased, especially during infectious disease pandemics. Meng et al. compared COVID-19 prevention and control measures between Shanghai and Beijing. The authors concluded that the social, governmental, and professional pandemic management approaches implemented should be further evaluated as different policies in these different areas were implemented and the adoption of prevention practices varied by location.

The COVID-19 pandemic tested not only medical and scientific capabilities but also highlighted the importance of psychological factors in public health. Maftei and Petroi's study in Romania provided key insights into this often-neglected area, especially regarding vaccination behavior and the interplay between optimistic bias, conspiracy beliefs, and public perceptions. Their study became particularly relevant when considering Romania's struggle during the 2021 COVID-19 surge, which saw Europe's highest death rates and low vaccination uptake. The study highlighted the importance of psychological factors affecting public health choices, examining relationships among optimistic bias, COVID-19 conspiracy theories, vaccination status, and other behaviors like online activity and anticipated regret. A notable outcome is the strong inverse relationship between optimistic bias and the perceived threat of COVID-19, indicating that individuals who downplay their personal risk are also less likely to see the pandemic as a severe threat, thus affecting their decisions about vaccination. This research emphasized the need to focus on both the logistical and medical sides of health crises and the psychological and informational contexts in which people make health decisions. Effective public health communication should counter misinformation, tackle psychological biases, and use sophisticated approaches to reach various demographic groups, especially in a time of widespread online misinformation.

Grant and Sams examined the impact of COVID-19 lockdown measures in Africa, highlighting the limitations of a "one-size-fits-all" approach. Utilizing social media analysis, the authors investigated the diverse reactions to lockdowns across the continent, emphasizing how these measures have highlighted and exacerbated existing inequalities. Their research, grounded in social listening, examined the narratives that emerged on platforms like Twitter during the initial lockdown phase in sub-Saharan Africa. The narrative surrounding the harms of lockdowns in Africa, as captured through social media, particularly emphasized the continent's poverty and weak health systems as key risk factors for the spread of COVID-19, as well as the adverse consequences of sustained lockdown measures. The authors argued that social media became a critical space for voicing concerns and sharing knowledge, especially when traditional communication channels were disrupted by lockdowns. Grant and Sams stressed that public health responses to pandemics often failed to account for local, national, and global structural inequalities. It was suggested that social media's role in amplifying diverse voices and facilitating innovative responses to health crises, such as crowdsourcing campaigns, should be applied in future health communication strategies. The findings also advocate for the development of behavior change communication campaigns that effectively use platforms like Twitter for disseminating critical information. By acknowledging the complexity of health messaging and the contradictions inherent in epidemic response policies, policymakers can better navigate the challenges posed by health threats.

The study by López-Güell et al. evaluated the impact of COVID-19 certification mandates on case incidence and hospital admissions across the United Kingdom, revealing varied effects influenced by regional dynamics and virus variants. Certification mandates, requiring proof of vaccination, a negative test, or recent infection for public venue access, were introduced at different times across England, Northern Ireland, Scotland, and Wales. The analysis identified a decrease in cases and hospitalizations, particularly during the Delta variant's predominance. However, the study found the intervention's efficacy diminished with the emergence of the Omicron variant, especially in England, where it was less effective in reducing case incidence and hospital admissions. The discrepancy in outcomes across the UK highlighted the complex interplay between public health measures, virus variants, and population behavior. The findings suggest that while COVID-19 certification mandates contributed to increased vaccination rates and reduced transmission during the Delta variant's prevalence, their impact was less significant against Omicron. Limitations included the aggregated nature of data and potential ecological fallacy, with the study cautioning against interpreting the results as

solely attributable to certification mandates due to coexisting measures and behavioral responses. The study underscores the necessity of a multi-faceted approach in pandemic management, combining certification with vaccination and other interventions tailored to evolving virus dynamics and regional contexts. It calls for continuous reassessment of public health policies to adapt to new challenges, emphasizing the importance of flexibility and evidence-based decision-making in controlling the pandemic's spread.

Kouyate et al. examined the access and use of maternal health services during the COVID-19 pandemic in Guinea. Their findings emphasize the critical need to sustain and enhance access to vital health services during a pandemic, especially for at-risk groups such as pregnant women. Initially, there was a decrease in the use of maternal health services during the early phase of the pandemic. However, some facilities later saw improvements following specific interventions including continuous training in infection prevention and control for healthcare workers, along with the distribution of delivery kits and resources during the crisis. These measures not only improved the capabilities of healthcare facilities but also boosted community trust in these services at a crucial time. The study also shed light on significant challenges, such as the inconsistent application of infection prevention strategies across various health facilities, including associated health centers, community health centers, and district hospitals. This inconsistency underscores the need for standardized health practices, especially in cleanliness and patient care protocols. Enhancing access to maternal health services during emergencies addresses immediate healthcare needs and contributes to the long-term resilience of the health system.

The COVID-19 pandemic highlighted the complex interplay between socio-structural factors and public health outcomes, as evidenced by the study conducted by Qamar et al. on COVID-19 incidence in Germany. This study sheds light on the subtle ways in which the local socio-economic environment and political opinions can greatly impact the transmission of diseases. Economic and social factors such as income, the percentage of individuals seeking protection or claiming social benefits, and the level of education seem to have minimal effect on disease occurrence rates. The association between the popularity of certain political parties and varying COVID-19 incidence suggests that public health responses and policies must consider local sociopolitical dynamics. The study advocates for a public health approach that is cognizant of these socio-behavioral factors, thereby enabling more targeted and effective interventions.

In Austria, the study by Ruf et al. examined the role of employers in influencing COVID-19 vaccine uptake among healthcare workers. Their research showed that while employers can act as influential mediators in public health decision-making, the process of choosing to vaccinate is complex and influenced by myriad factors including personal beliefs, world views, and political influences. This study sheds light on the concept of "unspoken vaccine hesitancy" among healthcare workers, emphasizing the need to create safe spaces for expressing concerns and hesitations about vaccination. The study reveals that while incentives and educational programs can increase vaccine willingness, addressing vaccine hesitancy requires a more effective approach that considers individual worldviews, political influences, and personal apprehensions. It suggests that employer-driven public health initiatives must be multi-faceted, going beyond mere information dissemination to include support systems and respect for individual decision-making processes. In doing so, it emphasized the role of employers as critical mediators in public health decision-making, especially in crisis situations like the COVID-19 pandemic.

The CRAB (COVID-19 Risk, Attitudes and Behavior) study in the Royal Navy, conducted by Woolley et al. offered insight into how knowledge, attitudes, and practices impact COVID-19 prevention. This cross-sectional analysis revealed a diverse mix of elements affecting adherence to preventive measures and reluctance to get vaccinated, emphasizing differences in how various demographic groups perceived the severity of the virus and their trust in different information sources. Key findings included lower COVID-19 seriousness ratings among male respondents and higher ratings among Black, Asian, and minority ethnic backgrounds. Among various information sources, the Defence Medical Services emerged as the most trusted for vaccine-related information. These insights are vital for understanding compliance, information credibility, and vaccine hesitancy within the Royal Navy and serve as a valuable resource for future studies on emerging infectious diseases. The research highlights the essential role of customized communication strategies in public health efforts, especially in closed, structured settings like the military.

Continuing with examining knowledge, attitudes, and perceptions, Khan et al. studied the influence of these factors on the Oxford AstraZeneca COVID-19 vaccine among primary healthcare workers in North-Central Trinidad. The main contributors to vaccine hesitancy included fear of adverse side effects, the feeling that clinical trials had not occurred for a long enough period of time, and the absence of information. Further, Fang et al. examined knowledge and attitude toward protective measures and the COVID-19 pandemic response via a questionnaire. The authors concluded that guidance should be communicated in different ways and depending on the risk presented by the health crisis, the frequency of the messaging should adapt accordingly.

The COVID-19 pandemic compelled health systems worldwide to adapt rapidly. A nationwide surveillance study in Taiwan, led by Chi et al. highlighted a significant shift in diagnostic policy during the COVID-19 epidemic from Polymerase Chain Reaction (PCR) testing to Rapid Antigen Tests (RATs). This policy change mirrored a global reevaluation of healthcare strategies in response to evolving challenges. The study underscored the vital role of RATs as a feasible, low-cost, and convenient diagnostic tool. These tests, which can be performed at home, reduced hospital visits, thereby preserving medical capacity for more severe COVID-19 cases. This work highlights the adaptive nature of health policy and its direct impact on public behavior and healthcare system strain.

Additionally, in Iran, Mohammadpour et al. conducted semi-structured interviews with healthcare experts and determined

that changes were needed in several areas to respond to a future health crisis including e-health development, evidence-based decision-making, funding, collaboration at the national and international levels, and attention to the needs of healthcare workers.

2 Brief research report

The Mississippi Recognizing Important Vaccine & Education Resources (RIVERs) project, reported by Meador et al. emerged as a pivotal study in overcoming COVID-19 vaccine hesitancy, particularly among marginalized populations in rural or remote areas. By coordinating community engagement and local leadership, the project achieved remarkable success, notably in Mississippi, where vaccination rates among Black communities surpassed those of their White counterparts. This success underscored the critical role of local efforts in public health strategies, demonstrating how targeted interventions, grounded in the trust and influence of community leaders, can effectively combat misinformation and foster vaccine acceptance. The RIVERs project's approach, prioritizing direct community involvement and utilizing a variety of communication methods, offers a replicable model for other regions facing similar challenges. The RIVERs project faced limitations due to data aggregation at the county level, resulting in low statistical power and a cautionary note on drawing broad policy conclusions. Additionally, it lacked consideration of crucial contextual factors like vaccination access outside the program and local vaccination policies. However, the RIVERs project highlighted the importance of adapting public health initiatives to the specific needs and social contexts of vulnerable populations, ensuring that interventions are not only accessible but also resonate with the community's values and concerns.

3 Review

During the COVID-19 pandemic, evidence demonstrated that people of a low socioeconomic background disproportionately experienced the social and economic impacts of the COVID-19 pandemic. Nyabundi conducted a literature review to examine the roles and perceptions of social relationship networks, including kinship, as safety nets in Kenya during the pandemic. This work highlighted the need to strengthen informal familial and social support structures, which proved to be resilient during the most challenging periods of the pandemic, including addressing the socio-economic challenges brought about by COVID-19.

Lin and Wang through their systematic review, revealed how stigma, associated with the COVID-19 pandemic, is disproportionately borne by marginalized groups such as older adults, ethnic minorities, and those with lower socioeconomic status, thus underscoring the role of systemic social power imbalances. Their study advocates for a Marxist criticism approach to understand and dismantle the economic and social structures that fuel stigmatization. The mechanisms by which COVID-19 survivors faced stigmatization was through enacted stigma from communities and internalized stigma, leading to discrimination, rejection, and mental health issues. Enacted stigma included community fear and rejection, especially towards individuals in public-facing roles, while internalized stigma resulted from the survivors' negative self-perception due to the pandemic's associated fears. This stigmatization was rooted in fear of the unknown and a lack of understanding about the virus, exacerbating social and psychological challenges for survivors. Lin and Wang call for an interdisciplinary and collective action-oriented approach. This not only aims to address and eliminate the stigma associated with health conditions like COVID-19 but also challenges us to confront and reform the underlying societal inequalities that allow such stigmas to flourish. Their work serves as a critical reminder of the importance of looking beyond individual attributes to the systemic forces at play in exacerbating social inequality and stigmatization, urging for a comprehensive renovation of our social care systems to ensure a more equitable society.

4 Policy and practice reviews

Despite the documented success of many public health policies (e.g., smoking bans), Humphries et al. state that there is a need for values and varied perspectives to be considered during the policy analysis process. In particular, the authors implemented the Intersectionality-based Policy Analysis (IBPA) framework, which examines problems and policy approaches via a guiding principles approach. The authors applied the IBPA framework to the COVID-19 pandemic specifically to examine racial conflict and resolution in the United States of America via a participatory approach that utilized reflection and open-ended questions. The authors report that the tool was useful in identifying problems or policies and their respective impacts on different population groups.

5 Opinion

Chatelan and Khalatbari-Soltani's commentary serves as a call for transforming the traditional approach in public health of targeting high-risk individuals through specific interventions. The authors stated that this method falls short in addressing the continuing health disparities seen in socially vulnerable groups, such as racial and ethnic minorities, or those of a lower socioeconomic status. The authors suggest adopting a dual strategy that not only focuses on interventions aimed at the general population but also gives special attention to programs for these vulnerable communities. The COVID-19 pandemic has highlighted the limitations of solely focusing on personal responsibility and broad population measures. Future public health interventions must be centered around the needs of the population and the social determinants of health that impact health outcomes.

6 Perspective

The study by Mortimer et al. is a reminder of the general impact of racism on public health. The authors remind us that as we navigate to the post COVID-19 pandemic, it is imperative that efforts to combat racism and related social determinants are placed at the forefront of public health strategy. The COVID-19 pandemic unmasked deep-rooted structural issues in public health, with racism emerging as a critical determinant impacting health outcomes and demonstrating how the pandemic exacerbated existing disparities and disproportionately affected racial and ethnic minorities. Factors such as residential segregation, economic insecurity, and discrimination have long been shaping the health outcomes of minority populations. The pandemic heightened the visibility of these pre-existing conditions and provided a unique opportunity to re-think and reform our approach to public health.

7 Conclusion

The research highlighted herein demonstrates research contributions from a unique time in our history where we had to respond and prevent a complex, multi-factorial health threat that disproportionately impacted the most vulnerable among us. The work that comprises the Research Topic, COVID-19 Pandemic and the Social Determinants of Health, represents important and impactful recommendations for how we should prepare for ongoing and future global health threats.

Author contributions

RMC: Conceptualization, Writing – original draft, Writing – review & editing. RR: Writing – review & editing. MK: Writing – original draft, Writing – review & editing.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Local socio-structural predictors of COVID-19 incidence in Germany

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Socio-economic conditions and social attitudes are known to represent epidemiological determinants. Credible knowledge on socio-economic driving factors of the COVID-19 epidemic is still incomplete. Based on linear random effects regression, an ecological model is derived to estimate COVID-19 incidence in German rural/urban districts from local socio-economic factors and popularity of political parties in terms of their share of vote. Thereby, records provided by Germany's public health institute (Robert Koch Institute) of weekly notified 7-day incidences per 100,000 inhabitants per district from the outset of the epidemic in 2020 up to December 1, 2021, are used to construct the dependent variable. Local socio-economic conditions including share of votes, retrieved from the Federal Statistical Office of Germany, have been used as potential risk factors. Socio-economic parameters like *per capita* income, proportions of protection seekers and social benefit claimants, and educational level have negligible impact on incidence. To the contrary, incidence significantly increases with population density and we observe a strong association with vote shares. Popularity of the right-wing party Alternative for Germany (AfD) bears a considerable risk of increasing COVID-19 incidence both in terms of predicting the maximum incidences during three epidemic periods (alternatively, cumulative incidences over the periods are used to quantify the dependent variable) and in a time-continuous sense. Thus, districts with high AfD popularity rank on top in the time-average regarding COVID-19 incidence. The impact of the popularity of the Free Democrats (FDP) is markedly intermittent in the course of time showing two pronounced peaks in incidence but also occasional drops. A moderate risk emanates from popularities of the Green Party (GRÜNE) and the Christian Democratic Union (CDU/CSU) compared to the other parties with lowest risk level. In order to effectively combat the COVID-19 epidemic, public health policymakers are well-advised to account for social attitudes and behavioral patterns reflected in local popularities of political parties, which are conceived as proper surrogates for these attitudes. Whilst causal relations between social attitudes and the presence of parties remain obscure, the political landscape in terms of share of votes constitutes at least viable predictive "markers" relevant for public health policy making.

KEYWORDS

COVID-19 incidence, SARS-CoV-2, socio-economic risk factors, social determinants of health, public health policy

1. Introduction

Socio-economic conditions have long been known to constitute epidemiological determinants (1), which is also the case within the context of epidemiology of viral infections (2), including the recent COVID-19 pandemic with a focus on incidence (3–5) or on fatalities (6, 7) as dependent outcome. Socio-economic factors such as income, wealth, and education have been spotted as fundamental causes of a wide range of health outcomes (1). However, within the context of the COVID-19 pandemic, researchers' attentions have additionally been drawn to socio-behavioral aspects and political attitudes as crucial predictors of the pandemic activity (8–11). Recently, within this latter context of COVID-19, migration background has been suggested to constitute an additional risk factor for SARS-CoV-2 infection (5) due to, e.g., social isolation and mistrust of the health system. It is likely that all the influencing variables mentioned are more or less strongly correlated with each other. Here, the term "socio-structural" is used to comprise socioeconomic as well as behavioral and political aspects. Knowledge is still rudimentary regarding the combination of the influencing factors mentioned. We here attempt to determine COVID-19 incidence depending on prevailing social attitudes captured by means of affinity to certain political parties and use the most important socio-economic factors in a multivariable regression model to control for possible correlations.

Previous analyses of socioeconomic determinants of COVID-19 incidences (and fatalities) exist for other countries like the USA (6) or Austria (12), however, the results might not be applicable to Germany. Other studies have been conducted at an early pandemic phase and need to be updated to the recent epidemic activity (3, 4, 11). In references (3, 4), a single aggregated parameter, the so called German Index of Socio-economic Deprivation (GISD), has been used as a predictor for COVID-19 incidence. Interestingly, the latter study revealed the more wealthy, i.e., less social deprivated sub-population as an early driver of the epidemic in Germany up to the so called "first wave," with a change to the opposite in the subsequent course of the epidemic. An obvious reason can be seen in ski tourism, which attracts more wealthy classes of society and which has been identified bearing an important epidemic driver function during the onset of the pandemic (13). In a seroprevalence study restricted to one German region (5), the focus was on ethnicity and adjustments for possible socio-economic confounders, however, leaving comparisons between regions pending. In the latter study, ethnicity as a significant risk factor has been concluded from an overproportionate seroprevalence of the corresponding subpopulation. Having said that, all socio-structural variables are strongly correlated, therefore, Ruck et al. (6) tried to shrink the set of variables down to the statistically most important subset using the least absolute shrinkage and selection operator (LASSO) regression method, however, with ambiguous meaning.

Apparently, Germany currently faces a prevalence of more or less unspecific gestures of political opposition (10), which resulted in the foundation of protest parties like the "Alternative for Germany" (Alternative für Deutschland, AfD). Recent studies suggest that regions with high popularity of the right-wing AfD exhibit higher COVID-19 incidences when being compared to regions with moderate or low AfD popularity (11). Similarly, a study focusing on the impact of vote shares in Austria (12) identifies correlations between political orientations and COVID-19 infection risk and/or mortality. Recent interview-based surveys confirm that radical opponents of anti-corona measures are over-proportionately attracted by the AfD (8–10). However, another large fraction of these opponents is constituted by people with strong concerns with respect to modern medicine or reject some medical interventions like vaccination completely as, e.g., anthroposophists (8–10). Frequently, this group refers to the self-healing power of humans to express their reservations about medical research achievements. Often, this sub-population has an affinity toward the Green Party (Bündnis90/Die Grünen) or similar parties with an emphasis on environmental and bio-ecological aspects (9).

Since previous quantitative analyses left some questions open with respect to potentially correlated socioeconomic factors, we here focus on a multivariable regression model for COVID-19 incidence and refrain from using a score parameter and instead aim at separately assessing crucial socio-structural parameters. Besides the share of votes, the set of covariates includes unemployment rate, educational level, proportion of refugees, proportion of welfare recipients, income, and population density. Among the available census parameters, the proportion of refugees (called "protection seekers" in the German census database) comes closest to the intended consideration of migration background. Including population density is motivated by the hypothesis that metropolitan areas, e.g., might be more prone to high incidences than sparsely populated rural areas. Thus, our analysis adds substantial insights with respect to existing studies, particularly to Richter et al. (11), due to its updating and rigorous methodical extensions.

Abbreviations: GISD, German index of socio-economic deprivation; BW, Baden Württemberg; MV, Mecklenburg-Vorpommern; NRW, Nord-Rhein-Westfalen; RP, Rheinland-Pfalz; SA, Sachsen-Anhalt; SH, Schleswig-Holstein; Low edu, lower degree secondary education; Middle edu, middle degree secondary education; High edu, higher education entrance qualification; AfD, Alternative for Germany; SPD, Social Democratic Party of Germany; CDU/CSU, Christian Democratic Union of Germany; FDP, Free Democratic Party; LINKE, The Left Party, Die Linke; GRÜNE, The Green Party, Bündnis 90/Die Grünen.

2. Materials and methods

2.1. Data

Publicly available data are used exclusively. Three age-stratified time series at the level of 411 rural/urban German districts (Landkreise, kreisfreie Städte) of the registered COVID-19 7-day-incidence (per 100,000 inhabitants) have been retrieved from the database provided by the Robert Koch-Institute (14). Final retrieval date has been Dec 1, 2021. Thereby, the three age classes (in years) [0–14] (referred to as kids), [15–19] (juveniles), and >19 (adults) are used. Of note, due to unobserved COVID-19 cases, these data do not contain true incidences. For the analysis, three episodes of the epidemic time course are used spanning report weeks [41–60], [61–80], and [81–100], respectively, where the report weeks are counted from the first week of 2020 onward. These episodes enclose so called epidemic waves 2, 3, and 4, respectively. Since the peaks of the waves differ among districts, the maximum incidence within each of the periods is used as outcome to be predicted, whereby the period enters the model as one of the independent variables. In a parallelly performed analysis, the cumulative incidences over each of the three periods ("epidemic waves") have been used as outcomes to be predicted, following the rational that the bulk of each period could be a better measure for the strengths of the epidemic waves. The age class is a further covariate. For brevity, we use "incidence" to refer to the 7-day-incidence per 100,000 inhabitants in the sequel.

Furthermore, socio-economic and census data have been retrieved from the Regional German Database (Regionaldatenbank Deutschland) operated by Federal and State Government Census Bureaus (Statistische Ämter des Bundes und der Länder) (15). The following data, retrieved at the rural/urban district level, have been used as independent variables:

- share of the vote (percentages) resulting from the European election 2019 available for the following parties: CDU/CSU, SPD, GRÜNE, AfD, LINKE, FDP, and Other Parties (cf. see abbreviations) focussing on eligible voters, voter turnout as well as valid second vote. The general vote statistic is established on a full census (Totalerhebung) and uses official transcripts as well as documents from electoral bodies (secondary statistics). In addition, the voter participation has been included to the set of covariates.
- unemployment rate (percentage) regarding the dependent workforce in 2020. The unemployment rate relates the numbers of registered unemployed people to the workforce (workforce and unemployees) as a quota given in percentage. The unemployment rate is focused on the dependent civil workforce, meaning all employees who are subject to social insurance including trainees (Auszubildende), minor (geringfügig) employees, and officials (Beamte) (excluding soldiers) including unemployed people. The data used is based on secondary statistics and gained through administrative processes by a complete survey (Vollerhebung) of regional employment agencies as well as registered people at the Jobcentre.
- graduates of 2019 within the population (percentages) holding particular degrees of education (w/o graduation, Hauptschulabschluss (lower degree secondary education), Mittelschulabschluss [middle degree secondary education), Hochschulreife (higher education entrance qualification)]: The data is based on a full census (Totalerhebung) due to the duty of disclosure for public as well as private schools.
- proportion of the population with the status of protection seekers in 2019 based on data of the Central register of foreigners (Ausländerzentralregister AZR).
- proportion of the population receiving social assistance benefits in 2020 (Empfänger von Hilfe zum Lebensunterhalt) based on a complete survey (Vollerhebung), as well as secondary statistics since already gathered administrative data, is being prepared.
- *per capita* income of private households in Germany from 1995 to 2019 provided by the task force "national accounts of federal states" (Volkswirtschaftliche Gesamtrechnungen der Länder) on behalf of 16 states' statistical offices, federal statistic office, and registration office, Frankfurt. The data used focuses on the primary income of private households including non-profit organizations per inhabitant measured in Euro in 2019.
- population density given by inhabitants per square kilometer (last database update 2021).
- the federal state to which a given district belongs serves as a further determinant.

Of note, data are provided in a consistent way with a nationwide coverage at the spatial levels of entire Germany, 16 federal states, and 411 rural/urban districts (or counties, "Landkreise" or "kreisfreie Städte" in German, respectively). Data are given in a fragmented way at other levels, e.g., cities or metropolitan areas and could, therefore, not be used. The 411 districts are the statutory COVID-19 reporting units which explains why for the regression analysis in the following these districts have been chosen as the "natural" geopolitical units. Furthermore, we added the population density as crucial correlate which allows for an adjustment of differences in agglomeration.

2.2. Statistical methods

Within the framework of an ecological study (16), linear random effects regression modeling (17) is used to predict the maximum incidence calculated at the rural district level within one of three pre-defined epidemic periods, depending on

the share of the vote. Of note, causal relations usually remain undetermined in ecological studies, which is why the typical paraphrase "prediction model" for a regression in which an outcome depends on an explanatory variable has to be taken with a grain of salt and preferably interpreted as an association. In a parallel (sensitivity) analysis, the cumulative incidences over the periods are used.

In addition, a linear random effects regression is applied in increments at each point in time (i.e., weekly) during the entire observation time in order to obtain the temporal behavior of the regression parameters. Predictors of the regression, i.e., possible risk factors or correlates, are the socio-economic parameters and covariates listed above. The district index has been supplied as random variable. Statistical modeling has been performed using the "lme4" package of "R statistical programming language" (version 4.1.2) (17, 18). We report the estimates along with their p-values derived from t-statistics (two-sided). Models are compared using likelihood ratio tests (LRT). Significance level is $\alpha = 0.05$. A summary table of descriptive statistics is presented along with univariate statistical tests (t-test for continuous and chi-squared for categorical variables).

The share of votes of all parties add up to 1. Taken as independent variables in a regression analysis, this entails some degree of multicollinearity. Based on the method "leave one variable out" a sensitivity analysis is performed. The full discussion of this matter will be moved to Supplementary Figure S4.

3. Results

The summary of socio-structural, demographic, and geographical characteristics included as independent variables in our regression analysis over all 411 rural/urban districts is compiled in Table 1. Hereby, the districts have been separated into districts with AfD share of vote below the median over all 411 districts and share of vote above the median. Obviously, all districts belonging to one of the five East German federal states have AfD share of votes above median. Some of the differences of the districts with high vs. low AfD share of vote with respect to the characteristics considered are significant in terms of univariate tests. Note, the p-values resulting from univariate tests are presented here for explorative reasons only, without adjusting for multiple testing. Consequently, some of the characteristics should be considered to be adjusted for in a regression model of COVID-19 incidence with the AfD share of vote as independent variable. This will be rigorously assessed in the following.

The scatterplot Figure 1A depicts maximum incidence within epidemic period [81–100] of the adult population vs. the share of vote of the AfD for the 411 rural/urban districts. The analogous scatterplot with maximum incidence replaced by cumulative incidence is shown in Figure 1B. The AfD enjoys high popularity in East Germany which gives rise to well-separated point clouds corresponding to these two regions. A comparably strong difference in share of vote between East and West can be observed for the left-wing party "Die Linken" (LINKE), whereas differences in share of vote are more moderate for the other parties, although not negligible (see the full set of scatter plots for the maximum incidence as outcome in Supplementary Figure S1 and cumulative incidence as outcome in Supplementary Figure S2, respectively).

The incidence of a rural/urban district significantly increases with the district's percentage of AfD-vote as shown in Figure 1 by means of linear regression lines. Thereby, we fitted regression lines to the full set of data yielding slopes s in Δincidence (s_{cum} in Δcumulative incidence) per percentage point ($s = 33.9$, $p < 0.0001$; $s_{cum} = 80.19$, $p < 0.0001$) as well as to the two subsets belonging to East ($s = 62.14$, $p < 0.0001$; $s_{cum} = 201.3$, $p < 0.0001$) and West Germany ($s = 16.72$, $p = 0.005$; $s_{cum} = 80.86$, $p = 0.0027$), respectively. It turns out, that the increase of incidence with increasing share of vote is by far stronger in East Germany, which suggests that the regions with their differing socioeconomic conditions might constitute a set of additional, possibly correlated, determinants, which will be analyzed in detail in the following.

In the same vein, for explorative reasons, we performed univariate linear regressions for all the other combinations of the triple set of predictors/correlates: party, epidemic period, age class. Please see the Supplementary Figure S1 for the full set of scatterplots using maximum incidence per period as outcome variable and Supplementary Figure S2 with the cumulative incidence as "bulk" measure of each period as outcome, including regression lines. A qualitative assessment of the results strikingly reveals a dominant impact of the share of vote of the AfD. However, particularly the obvious differences observed for East and West Germany entail a rigorous multivariable regression beyond these explorative univariate analyses, including the required adjustments.

In a first step, a full multivariable linear random effects regression model including the following independent variables is fitted to the age-stratified (using three age classes) COVID-19 incidence data given at rural/urban district resolution:

- share of vote per party excluding "other parties" (cf. section Methods),
- federal state,
- age class with kids as reference,
- epidemic period with weeks [41–60] as reference,
- unemployment rate,
- proportion of protection seekers,
- proportion of social benefit claimants,
- proportion of population with a given level of education excluding the group "w/o graduation,"
- *per capita* income,
- population density.

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TABLE 1 Summary table of characteristics (first column) of rural districts with AfD share of vote below the median value taken over all 411 German districts (second column) and above median (third column), respectively. For an explanation of the characteristics confer the Methods section.

	≤Median (N = 206)	>Median (N = 205)	Total (N = 411)	p-Value
EAST/WEST				< 0.001
EAST	0 (0.0%)	76 (37.1%)	76 (18.5%)	
WEST	206 (100.0%)	129 (62.9%)	335 (81.5%)	
Federal state				< 0.001
Bayern	66 (32.0%)	30 (14.6%)	96 (23.4%)	
Berlin	7 (3.4%)	5 (2.4%)	12 (2.9%)	
Brandenburg	0 (0.0%)	18 (8.8%)	18 (4.4%)	
Bremen	1 (0.5%)	1 (0.5%)	2 (0.5%)	
BW	16 (7.8%)	28 (13.7%)	44 (10.7%)	
Hamburg	1 (0.5%)	0 (0.0%)	1 (0.2%)	
Hessen	9 (4.4%)	16 (7.8%)	25 (6.1%)	
MV	0 (0.0%)	9 (4.4%)	9 (2.2%)	
Niedersachsen	38 (18.4%)	7 (3.4%)	45 (10.9%)	
NRW	34 (16.5%)	19 (9.3%)	53 (12.9%)	
RP	16 (7.8%)	20 (9.8%)	36 (8.8%)	
SA	0 (0.0%)	14 (6.8%)	14 (3.4%)	
Saarland	3 (1.5%)	3 (1.5%)	6 (1.5%)	
Sachsen	0 (0.0%)	13 (6.3%)	13 (3.2%)	
SH	15 (7.3%)	0 (0.0%)	15 (3.6%)	
Thüringen	0 (0.0%)	22 (10.7%)	22 (5.4%)	
Unemployment				< 0.001
Mean (SD)	5.65 (2.33)	6.66 (2.55)	6.15 (2.49)	
Range	2.40–12.80	2.20–16.20	2.20–16.20	
Protection seekers				0.541
N-Miss	1	2	3	
Mean (SD)	0.02 (0.01)	0.02 (0.01)	0.02 (0.01)	
Range	0.01–0.13	0.00–0.11	0.00–0.13	
Soc. Benefit claim.				0.011
N-Miss	1	2	3	
Mean (SD)	0.00 (0.00)	0.00 (0.00)	0.00 (0.00)	
Range	0.00–0.01	0.00–0.01	0.00–0.01	
***Per capita* income**				< 0.001
N-Miss	0	1	1	
Mean (SD)	30199.24 (5212.83)	26438.84 (4553.45)	28328.21 (5239.72)	
Range	19048.00–52783.00	18326.00–47353.00	18326.00–52783.00	
Higher edu				0.014
Mean (SD)	0.34 (0.10)	0.32 (0.08)	0.33 (0.09)	
Range	0.00–0.59	0.00–0.64	0.00–0.64	
Without edu				< 0.001
Mean (SD)	0.06 (0.02)	0.08 (0.03)	0.07 (0.02)	
Range	0.02–0.13	0.03–0.15	0.02–0.15	
Middle edu				0.004
Mean (SD)	0.42 (0.07)	0.45 (0.07)	0.43 (0.07)	
Range	0.22–0.61	0.20–0.65	0.20–0.65	
Low edu				0.035
Mean (SD)	0.17 (0.05)	0.16 (0.05)	0.17 (0.05)	
Range	0.08–0.40	0.06–0.32	0.06–0.40	
Population density				0.052
Mean (SD)	718.38 (982.44)	544.87 (817.98)	631.84 (907.23)	
Range	40.00–4790.00	36.00–4112.00	36.00–4790.00	

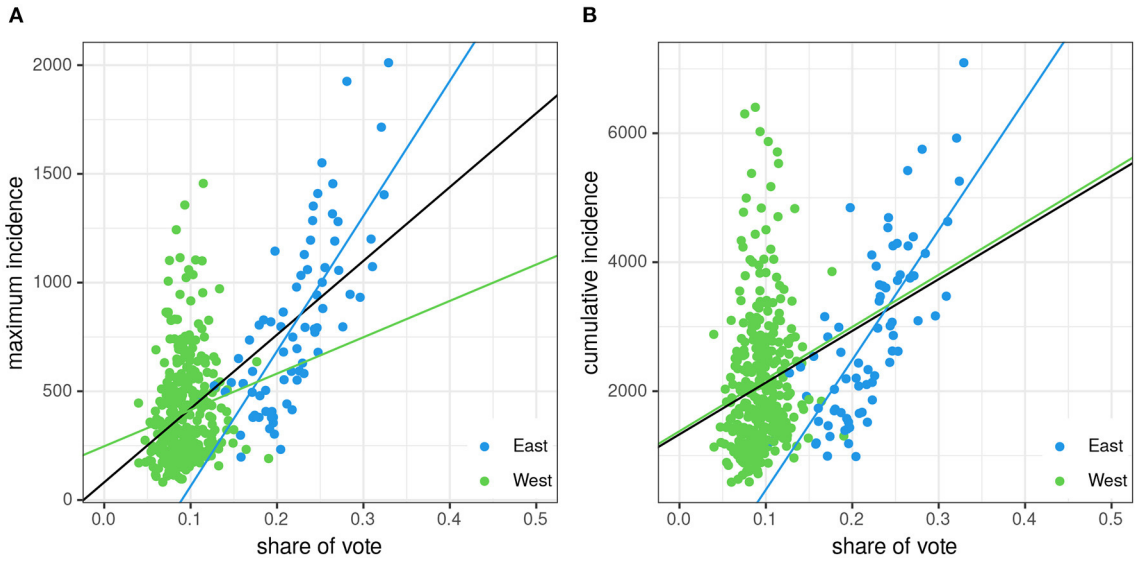

FIGURE 1
Maximum 7-day-incidence per 100,000 **(A)**/cumulative 7-day-incidence per 100,000 **(B)** within/over the epidemic period [81–100] of the adult population by the AfD share of vote for the 411 rural districts. Data points corresponding to East German districts are depicted in blue, West German districts in green. Three linear regression lines are shown for the full set of points (black), only the East German (blue), and only the West German (green) parts, respectively.

As before, we parallelly used the maximum incidence and the cumulative incidence as outcome variable, respectively. The resulting parameters and p-values are reported using the "/" as separator for the two cases, i.e., "value for maximum/value for cumulative" incidence. Instead of using the two-level factor East/West we switched to the federal state with 16 levels, which proved necessary according to a LRT ($p < 10^{-4}/p < 10^{-4}$). Thus, also North-South gradients in the percentage of votes for distinct parties as well as incidences can be observed. Thereby, unemployment rate, proportion of protection seekers, *per capita* income, as well as the proportion of social benefit claimants all turn out to constitute non-significant risks with $p > 0.55/p > 0.60$ for all corresponding p-values obtained by means of a LRT. In addition, skipping all these aforementioned variables simultaneously from the list of covariates and comparing full and reduced model fits yields $p = 0.98/p = 0.93$ resulting from a LRT.

Likewise, the educational level does not pose a high risk of elevating the incidence above the average. However, the proportion of the population with a low degree graduation may be conceived as a relevant correlate with an estimate of $\beta = 5.84$ ($p = 0.08$)/$\beta = 23.08$ ($p = 0.18$), although below statistical significance (see Table 2). Therefore, education is kept within the list of relevant covariates, however, unemployment rate, proportion of protection seekers, and proportion of social benefit claimants are removed due to their irrelevance. To the contrary, population density turns out as a relevant covariate ($\beta = 0.03$, $p = 0.003/\beta = 0.31$, $p < 0.001$), as expected (see Table 2). In full analogy to Supplementary Figures S2, S3 contains all individual univariate correlations "cumulative incidence vs. socio-economic parameter" for all age classes and periods, respectively.

The reduced model resulting from the model reduction process described above yields the results listed in Table 2. The most striking result of the regression is the highly significant effect of the AfD's share of vote for the prognosis of COVID-19 incidence. Even after inclusion of several socioeconomic and epidemiological covariates, a strong risk of high incidences can be observed when being compared to the share of vote of other parties.

Due to the constraint that the percentages sum up to 100%, the impact has to be interpreted in a relative sense. More specifically, this constraint may entail some degree of multicollinearity [cf. (19)]. However, a perfect multicollinearity would be present if and only if the coefficients of collinearity would be identical for all districts. In contrast, the 411 German rural/urban districts exhibit considerable heterogeneity in terms of popularity of parties expressed by their share of votes. A common procedure to assess the degree and impact of multicollinearity is to drop one of the variables from the set of covariates. The full discussion of the results obtained from a corresponding sensitivity analysis is moved to Supplementary Figure S4. To summarize the result, leaving one party out leads to an approximately constant shift of the values of the regression parameters of the remaining covariates, whereby the magnitude of the observed shift depends on the

TABLE 2 Result of a linear random effects regression predicting maximum incidence (estimates indicated by "max") or cumulative incidence (estimates indicated by "cum"), respectively, per epidemic period.

	Predictor	β (max)	p-Value (max)	β (cum)	p-Value (cum)
Federal state	Bayern	0.395	0.999	3286.174	0.143
	Berlin	-34.611	0.939	3210.232	0.167
	Brandenburg	115.055	0.801	3636.901	0.120
	Bremen	30.711	0.947	3831.774	0.108
	BW	19.867	0.965	3524.750	0.127
	Hamburg	-39.974	0.932	3438.733	0.153
	Hessen	-57.591	0.899	3304.622	0.157
	MV	-63.378	0.890	3019.638	0.201
	Niedersachsen	-43.469	0.924	3118.805	0.183
	NRW	-7.703	0.987	3604.655	0.125
	RP	17.159	0.970	3505.172	0.129
	SA	140.166	0.756	3651.953	0.115
	Saarland	96.533	0.834	3991.444	0.092
	Sachsen	287.240	0.529	4431.647	0.059
	SH	-143.821	0.750	2434.284	0.293
	Thüringen	123.857	0.788	4271.552	0.071
Age class	Juveniles	78.969	<0.001	839.001	<0.001
	Adults	-112.772	<0.001	-239.226	<0.001
Period	[61–80]	-3.253	0.759	-374.344	<0.001
	[81–100]	445.519	<0.001	1217.538	<0.001
Education level	Low edu	5.842	0.080	23.084	0.177
	Middle edu	3.735	0.199	12.294	0.409
	High edu	4.091	0.152	15.196	0.298
	Population density	0.033	0.003	0.312	<0.001
Share of vote	AFD	24.537	<0.001	101.449	<0.001
	SPD	-9.256	0.023	-58.548	0.005
	CDU	2.263	0.552	2.694	0.890
	GRÜNE	3.242	0.480	8.521	0.717
	LINKE	-12.623	0.027	-107.939	<0.001
	FDP	-16.895	0.010	-100.145	0.003
	Vote participation	-4.417	0.002	-39.023	<0.001

Reference levels of the categorical predictors are: kids for age class and weeks (41–60) for epidemic period. The metric covariates are given in %, thus the corresponding βs have to be interpreted as Δincidence (or Δcumulative incidence, respectively) per percentage point. Due to the constraints that the percentages corresponding to share of vote and education, respectively, sum up to 100% we skipped the variables "Other Parties" and "w/o graduation" in order to avoid singularities. The random effect of the rural districts yields a standard deviation of 28.23 ("max") and 319.7 ("cum") for the intercept and 262.4 ("max") and 1036.6 ("cum") residual.

omitted party. The observation of such a bias in moderately collinear covariates is a known phenomenon, consequently, the estimates have to be interpreted in a relative sense. Inferences drawn from these results are unchanged when being compared with the inferences drawn from the full model.

In this line, CDU/CSU as well as GRÜNE rank between AfD and the other parties in terms of the magnitude of risk. Obviously, rural/urban districts with high percentages of votes of the AfD exhibit characteristics that constitute risk factors for COVID-19 incidence. The increasing risk resulting from an increasing popularity of CDU/CSU and GRÜNE is more moderate or neutral, whereas the increasing percentages of the other parties seem to unfold a lowering in risk of incidence. Independently, of whether the local characteristics that determine higher incidence rates are directly related to the political agenda of the corresponding parties or not, the very fact of increased incidences entails that the politicians are in charge to reflect these characteristics of their districts.

The impacts of most of the other covariates are not very surprising. Saxony (Sachsen) faced the by far highest incidence during the fourth wave (weeks [81–100]), whereas Schleswig-Holstein (SH) exhibited an incidence well below the country average, consistent with the observed statistical significance of the two federal states and the epidemic period,

respectively. Of note, an increasing vote participation turns out to statistically significantly lower the risk of COVID-19 incidence. A shared hostile stance with respect to public health and other policies between AfD voters and non-voters might by a possible, although speculative interpretation. To complete the report, the random effect of the rural/urban districts yields a standard deviation of 28.23/319.7 for the intercept (262.4/1036.6 residual), hence pointing to a considerable random variation between the districts not captured by the fixed effects of the model.

In a second explorative approach, we applied the random effects linear regression at each instant of time in order to obtain time series of the regression parameters. The rational behind doing so is to reveal possible temporal effects with impact on the prediction. The result is shown in Figure 2. The dominant role of the AfD share of vote in being positively correlated with incidences can be confirmed: the magnitude of the corresponding regression parameter almost persistently remains on top from end of 2020 on (Figure 2, second panel). This "time-dependent" regression also reveals a short period (around week 90) in which the Free Democratic Party (FDP) is on top. The moderate risk emanating from the GRÜNE and CDU/CSU can now apparently be attributed to the last episode roughly from week 90 onward.

The remaining two panels of Figure 2 are devoted to show the time courses of estimated effects corresponding to federal state, age classes, and unemployment rate. The latter effect remains well below significance throughout the entire observation time and has here been chosen as a proxy for all the other socio-economic determinants. All included socio-economic parameters do not show any role on predicting COVID-19 incidence after week 40. The federal states as well as the age classes, however, turn out to be significantly predictive from this time-dependent version of regression modeling as well, as already shown above where we aggregated the incidence time series into maximum or cumulative values of three dominating periods. Apparently, phases of higher and lower incidences alternate in an almost reciprocal way between West and East German states. Kids and juveniles play an increasing role as correlate with high incidences, most likely due to the increasing vaccination rate of the adult cohorts, but periods of school closures and openings and unstable interventions may also play a decisive role.

4. Discussion

We have shown that a multivariable linear random effects regression modeling yields popularity of the AfD (in terms of share of the vote) as a covariate significantly correlated with high incidence even after adjustment for several socioeconomic covariates. In contrast, an increasing percentage of votes for most of the other parties is associated with a reduced COVID-19 incidence with the exceptions of Christian Democratic Union (CDU/CSU) and the Green Party (GRÜNE) whose percentage of votes are insignificant in absolute terms for predicting the incidence. However, due to the constraint that percentages of votes sum up to 100% the results have to be interpreted in a relative sense. Thus, in relative terms, popularity of the AfD is strongly correlated with an increase in incidence, whereas popularity of CDU/CSU or GRÜNE is associated with medium risk, respectively, and the lowest risk emanates from the other parties.

One of the limitations of this analysis is the fact that correlations do not allow to draw inferences on causality. However, a comprehensive sociological interpretation is beyond our aim which is driven by the demand to supply relevant information for public health policies. From this point of view it is crucial to be able to spot locally given conditions that are informative for epidemiological control strategies, whether these conditions have causal or mere correlative structures.

Furthermore, our analysis is limited by the fact that the officially registered incidences depend on local COVID-19 test policies and the corresponding infrastructural conditions. Policies with respect to opening of schools and corresponding test strategies are particularly important since the impact of kids and juveniles as possible epidemic drivers is controversially debated (20–25). However, it seems more plausible that the average frequency of testing is even less in regions with a high "anti-corona attitude" prevalence, which thus would even amplify our result. Having that said, an in-depth analysis of the impact of both children-related policies and epidemic dynamics is encouraged.

In addition, the usage of aggregated data (proportions and population averages) might limit validity. Therefore, we engage the reader in relating our result with the insights gained by surveys based on individual interviews (8–10). We focused on predicting local incidences, however, it is suggested to also include fatalities in future studies [for a seminal work see (6, 7)].

Another limitation is the neglect of pandemic-relevant working conditions or high-risk occupations. For example, meat processing plants proved to be pandemic hotspots both in Germany and the USA (26–28). As far as Germany is concerned, there is a lack of reliable information on the spatial distribution of corresponding industrial branches. Access to reliable information regarding the spatial coverage of nursing homes and comparable vulnerable facilities turns out to be similarly problematic. However, a strong correlation with the spatial distribution of vote shares does not seem very plausible. More generally, due to limited availability of detailed socio-cultural variables and in order to avoid difficult to analyze hierarchical correlation structures of these variables, we have decided to differentiate the common German index of socio-economic deprivation only to a manageable degree by including the arguably most important components. We further assume that controlling for federal states and the

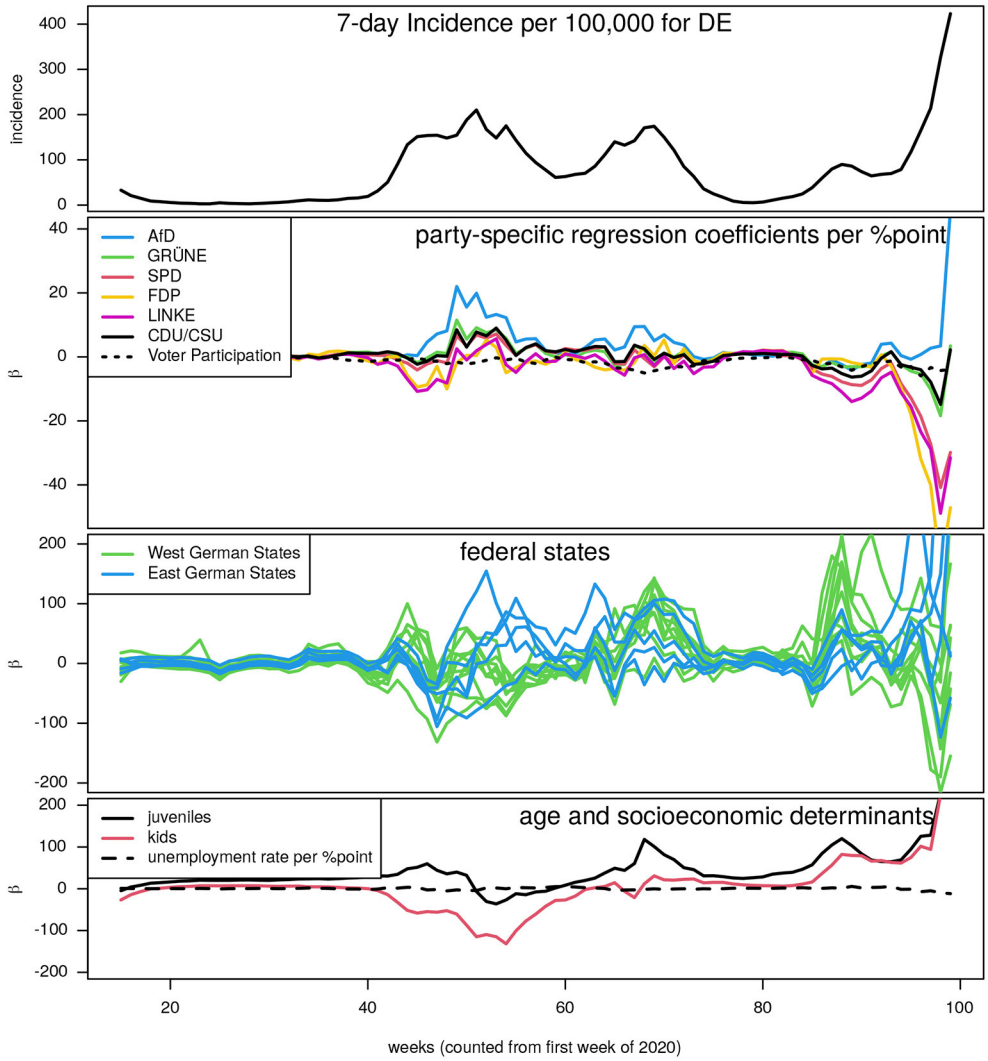

FIGURE 2
Time courses of regression parameters obtained from random effect linear regression modeling sequentially applied at all available time points during the observation time. Panel on top: the German COVID-19 7-day-incidence per 100,000 curve (to allow for a mapping of the results to the epidemic history). Other panels from top to bottom: regression parameters in units "per percentage point" corresponding to (i) the share of votes (including voter participation), (ii) the federal states (for a better visibility all West German states depicted in green, East German states in blue), (iii) age classes (adults are reference) and percentage of unemployment.

selected socio-structural variables constitutes a sufficiently good basis for a reliable regression. However, we advocate conducting in-depth multi-variable analyses as reliable data becomes available.

Finally, we did not include vaccination coverage in our analysis due to unavailable high-quality data with required spatial resolution. However, rough estimates regularly published by the Robert Koch-Institute on their online COVID-19 dashboard (29) suggest that incidence and vaccine coverage is negatively correlated. In addition, vaccine coverage might have an impact on hospitalization and severe COVID-19 illness, but is arguably considerably less important as protective factor for asymptomatic infections since the SARS-CoV-2 immunization is generally not sterile. Importantly, in our context, AfD-politicians officially propagate an anti-vaccination attitude consistent with findings in related surveys (8–10), which thus renders a significant impact of vaccination coverage on our main result as very unlikely.

In the same line, other locally differing COVID-19 containment strategies may play roles in predicting incidences. However, thorough research to determine locally applied containment measures revealed inconsistency coupled with opaque documentation. In this context, it is appropriate to point out the discrepancy between rule and compliance and it

appears to be likewise important to determine which factors drive (non-)compliance (30), so that we have again arrived at the political culture. Once again, it is plausible that most of these local differences are already contained in the popularities of certain parties as appropriate surrogate measures. Generally, the legislative responsibility for containment measures is at the federal state level in Germany. Therefore, as mentioned above within the context of the industrial landscape, we are convinced that the federal states already take sufficient account of the need for adjustment. A reliable evaluation of the aforementioned aspects within the scope of our ecological study appears impracticable, therefore, we refrain from comprehensive sociological analyses and refer to published work instead (8–11, 31) where motivations of the protest movement have been discussed. In reference (31), the Austrian situation is discussed revealing an impact of the right-wing party FPÖ similar to the German AfD. In following the cited literature, the prevalence of conspiratorial attitudes is above average among the new protest movement which might in turn be intensified by the extensive use of new media communication tools [cf. (32, 33) for a critical discourse, also see (31)].

Of note, we refrained from presenting an analog analysis using logarithmized 7-day-incidences as outcome since checks hereof led to irrelevant differences only. Finally, we did not consider spatial correlations. Although we do not regard this as a serious limitation it might be worthwhile to elaborate on this aspect in future studies based on spatial regressions.

5. Conclusions

Conclusive inferences have to be drawn with utmost care. The presented analysis of sociostructural risk factors aims in informing public health and epidemiology policymakers. We refrain from any accusation which appears to be inappropriate due to unclear causality. We use the share of the vote of a particular party as an approximate surrogate parameter that presumably captures sociobehavioral aspects and correlates with COVID-19 incidence beyond other socioeconomic factors and we strongly advocate a subsequent reflection of our results from a sociopolitical perspective, including representatives of the corresponding parties. We adopt the conclusions from a similar study (12) focusing on the impact of vote shares in Austria: "While these parameters are apparently only single elements of complex causal chains that finally lead to individual susceptibility and vulnerability levels, our findings might have identified ecological parameters that can be utilized to develop fine-tuned communications and measures in upcoming challenges of this and other pandemics."

Specifically, locally observed high COVID-19 incidences are associated with local popularity of the right-wing party AfD. Multivariable linear random effects modeling with adjustments for the most important socio-economic public-health determinants and the inclusion of epidemiological covariates yields a high degree of reliability of this result. It is particularly worth of note that a set of the most important socio-economic factors plays a minor role in driving the epidemic. As expected, population density has a statistically significant impact on COVID-19 incidence, however, an adjustment of estimates of the other correlates including the share of votes cannot be observed and we thus conclude that the share of votes are not correlated with population density. Speculatively, social and anti-governmental attitudes play a more important role where the popularity of a party can be conceived as a proper surrogate measure [cf. (8, 10)].

Local popularities of other parties by means of their share of vote lead to much weaker or even negative associations with COVID-19 incidences within the corresponding rural districts, with the exceptions of CDU/CSU and GRÜNE. In addition, during a short period of time the popularity of the FDP appears to pose a risk of increased COVID-19 incidence.

To conclude, COVID-19 incidence appears to be age-dependent. Incidence is higher amongst adolescents when being compared with the younger kids and the adults throughout the course of the epidemic. In agreement with the information provided at the online dashboard operated by the Robert Koch-Institute [RKI, (29)], the adults' incidence continued to stay below the children's incidence from the start of the vaccination campaign onward. However, the age-stratified incidence curves exhibit a waxing and waning in the course of time which certainly reflects corresponding regulations at schools and daycare facilities for children. Partially, age-specific measures and regulations also depend on local policies and, therefore, at least in part on locally prevalent social attitudes. Thus, we herewith encourage further studies into spatio-temporal epidemic dynamics that account for the spatio-temporal variability of related epidemiological containment policies which is urgently needed for a comprehensive understanding not only of the SARS-CoV-2/COVID-19 pandemic but also for being prepared for similar potentially disastrous public health challenges in the future.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: survstat.rki.de and regionalstatistik.de.

Author contributions

HD and NT: conceptualization, methodology, formal analysis, and supervision. HD: software and writing–original draft preparation. AQ and LG: resources and data curation. HD and AQ: visualization. NT: project administration. All

authors: validation and writing–review and editing. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2022.970092/full#supplementary-material

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Improving access to and use of maternal health services during COVID-19: Experience from a health system strengthening project in Guinea

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The purpose of this study was to document the experience of health providers' capacity strengthening during health crises and the contribution of such to the health system and the population resilience in the face of the COVID-19 pandemic in Guinea. We conducted a cross-sectional study using routine data collected from 41 health facilities in the project intervention areas, including associative health centers, community health centers, and district hospitals,. These data covered the period between 2019 and 2021. Results showed that all the community health centers (CMCs) had a clean internal and external environment, compared to health centers (95.2%) and district hospitals (33.3%). Hand washing was systematic among visitors attending CMCs and district hospitals (HPs). However, 28.6% of visitors attending associative health centers (AHCs) did not wash their hands. Temperature taking for visitors was not carried out in all CMCs and in 90.5% of the AHCs; unlike in the HC and HP where the temperature of each patient was taken before entering the consultation room. The obligation to wear masks was higher in the HP and in the HC, compared to the CMC and AHC where the order of non-compliance with the wearing of masks was, respectively 36.4 and 19%. Non-compliance with social distancing in the waiting rooms and between users was observed in all facilities. The project's interventions mainly contributed to improving the utilization of prenatal consultation and institutional delivery services; the beginning of the interventions was marked by an increase of an average of 17 ANC1 per month in CMCs and 116 ANC1 in health centers. Ongoing training on capacity strengthening for providers in infection prevention and control, followed by the offering of delivery kits and materials during epidemics, would contribute to the improvement and utilization of health facilities by the population.

KEYWORDS

COVID-19, maternal health, antenatal care, institutional delivery, Guinea

Introduction

The new coronavirus disease (COVID-19) emerged in China in mid-December 2019 and then spread rapidly worldwide, resulting in more than 552 million confirmed cases and 6 million deaths as of July 2022. According to recent World Health Organization (WHO) estimates, major disruptions in the utilization of maternal health services have been observed in 40% of countries in sub-Saharan Africa (SSA) (1). Authors have reported a decline in maternal health indicators between 3–12%,—including antenatal care, and institutional deliveries—during COVID-19 in eight SSA countries (2). Another study in Rwanda found that health facilities in rural areas were the most affected by the decline in the utilization of antenatal care services and institutional deliveries (3).

In Guinea, the first case of COVID-19 was recorded on March 12, 2020. As of 21 July 2022, a total of 724,638 confirmed cases and 783 deaths have been recorded nationwide (4). The country was the epicenter of the West African Ebola epidemic in 2014/2016. This epidemic had a drastic effect on maternal health services, particularly in rural areas (5–7). The main reasons for this decline in utilization of health services included people's fear of contracting the disease in health facilities; and the closure of health facilities due to the death of health workers or lack of personal protective equipment (8). Like the Ebola epidemic, the COVID-19 pandemic could lead to disruptions in the use of maternal services, particularly for populations living in rural areas (9).

However, an analysis of health services utilization during the first month of the COVID-19 pandemic declaration in Guinea (April 2020), showed a sharp decrease in first and subsequent outpatient visits in Conakry as well in the regions of Kindia, Mamou, and Labé where cases were reported (source SNIS).

To reduce the effects of the COVID-19 pandemic on the use of maternal health services, a project entitled "Strengthening the Health System to Ensure Continuity of Services and Access to Care for Vulnerable Populations in the Context of COVID-19" was implemented in Guinea. This 23-month project was piloted by the NGOs Memisa (Belgium) and Fraternité Médicale Guinée (FMG) in 41 health facilities across 4 administrative regions of the country (Conakry, Kindia, Mamou, and Labé).

In Guinea, Conakry was and continued to be the epicenter of the COVID-19 pandemic. The Health system in the capital is characterized by a proliferation of informal health facilities. This proliferation is sustained by the mismatch between health providers' supply and employment capacities of the government, as well as poor health system governance. In addition, the health system in Conakry is also characterized by a lack of communication that hinders the complementarity of actors in their common goal (improving the quality and accessibility of health care and services).

In the project areas, four (4) main interventions were undertaken:

- Training of health personnel in infection prevention and control, primary health care in emergencies including reorganization of care and patient flow;
- Providing health facilities with infection prevention and control equipment (masks, hydroalcoholic solutions, hand washing kits, personal protective equipment, etc.) and delivery equipment (delivery tables, carts, delivery boxes, etc.,).
- The provision and installation of incinerators and boreholes in health facilities;
- The provision of delivery kits (buckets, soap, clothes for newborns, etc.,) to women giving birth in health facilities.

This study was therefore undertaken to document the project's contribution to strengthening the resilience of the health system and the population during the COVID-19 pandemic. Specifically, this study aimed to:

- Describe the practices of health care providers with respect to ICP after the implementation of the Memisa health system strengthening project interventions.
- Analyze the effects of the Memisa project interventions on maternal health indicators (ANC1, ANC4 and institutional delivery), describing and comparing the period before COVID-19, during COVID-19 and the intervention.

The results of such a study could guide future public health interventions to improve the utilization of health services by populations in health emergency context.

Materials and methods

Study design

This was a cross-sectional study using routine data from maternal health services, and blinded observations of health care workers regarding the implementation of infection prevention and control (IPC) measures. Routine data covered the pre-COVID-19 period (March 2019 to February 2020), COVID-19 and pre-intervention period (March 2020 to March 2021), and COVID-19 and intra-intervention period (April 2021 to December 2021).

Study setting

General setting

Guinea is located in West Africa, with a population of over 12 million people (10) and a literacy rate of 31% for women and

55% for men. Women make up 53 % of the general population and those of childbearing age make up 45 % of the total female population. The country has high maternal and neonatal mortality rates with 576 maternal deaths per 100,000 live births and 31 neonatal deaths per 10,000 live births in 2017 (11). The total fertility rate is estimated at 4.8 children per woman with a total fertility rate of 165 births per 1,000 women of childbearing age per year (10).

Guinea has 8 health regions (Conakry, Kindia, Labe, Mamou, Boke, Kankan, Faranah, and N'zérékoré) divided into 38 health districts, 33 of which are rural. The country's health pyramid is structured into three distinct levels of care: primary, secondary, and tertiary. The primary level includes 414 government health centers, and a dozen community medical cabinets and associative health centers; the secondary level includes 4 communal medical centers, 26 district hospitals, and 7 regional hospitals; and the tertiary level includes 3 national or reference hospitals.

Maternal health service delivery in Guinea

Maternal health services in Guinea's health facilities are aligned with international guidelines for quality care (12). These guidelines define minimum packages of maternal health services by type of health facility. For example, primary health care facilities provide antenatal care (ANC) and eutocic deliveries. Emergency obstetric care for complicated deliveries (including cesarean sections) is required for secondary and tertiary health facilities. In addition, at least four ANC visits are recommended for each pregnant woman and at least 90% of all deliveries should be performed in health facilities (13). In addition, national guidelines recommend that qualified health personnel, including midwives, conduct deliveries in health facilities doctors, nurses, and technical health workers.

Specific setting

The health facilities in the intervention zones of the "Strengthening the health system to ensure continuity of services and access to care for vulnerable populations in the context of COVID-19 in Guinea" project served as the setting for this study. 41 health facilities, including 32 in the private sector and nine in the public sector, in four health regions, benefited from the interventions of the above-mentioned project. These health facilities are distributed as follows: 11 community medical cabinets; 21 associative health centers in the city of Conakry; six public health centers, two district hospitals (Pita and Télimélé) and the regional hospital of Labe.

Population and period of study

Quantitative data collection focused on women who used maternal health services between March 2019 and December 2021 in all facilities in the intervention zones and facility observations on infection prevention and control measures. Data were collected over a three (3) week period from January 23 to February 11, 2022.

Sampling

The sampling was exhaustive; all the health facilities in the intervention zone and benefiting from the project intervention were selected for data collection. These were 41 health facilities, including 11 COMEC-Gui community medical cabinets; 17 associative health centers in the city of Conakry of the Actions Concertées pour la Santé (ACS) network; Maferinyah health center, the HCs of Pita and Télimélé, Labe regional hospital, and the district hospitals (Pita and Télimélé) (Figure 1).

Data collection

Routine data on maternal health indicators were extracted from the district health information system (DHIS2) for each of the health facilities concerned. However, to ensure good data quality and reduce bias due to missing data, the monthly reports of the health facilities concerned were also used. Data extraction from the two sources mentioned above was done using forms previously established for this purpose. Both data sources were used to minimize the missing data sometimes encountered in the DHIS2. We did not compare the data from the two sources.

An observation of the providers' practices and the internal and external environment of the facilities was carried out using an observation grid. This observation grid was composed of 18 measures of infection prevention and control. These measures could be categorized into two main themes: patients' safety and security; and facility hygiene. Patient safety and security categories comprised (Is there an area in the facility for sorting incoming patients, are the providers wearing the correct PPE such as gowns, masks, gloves). Meanwhile, facility hygiene was composed of (Is the external and internal environment of the facility clean, Is there running water in the facility) applications, including the assessment of the internal and external environment, patient sorting areas, the presence of handwashing devices at the entrance of the facilities, the use of handwashing kits by visitors to the health facilities, the taking of temperatures by visitors upon entering the facility, the wearing of masks by patients and health care providers, physical distancing, and waste sorting. These observations took place approximately 12 months after the providers were trained in IPC. The observation grids were administered by

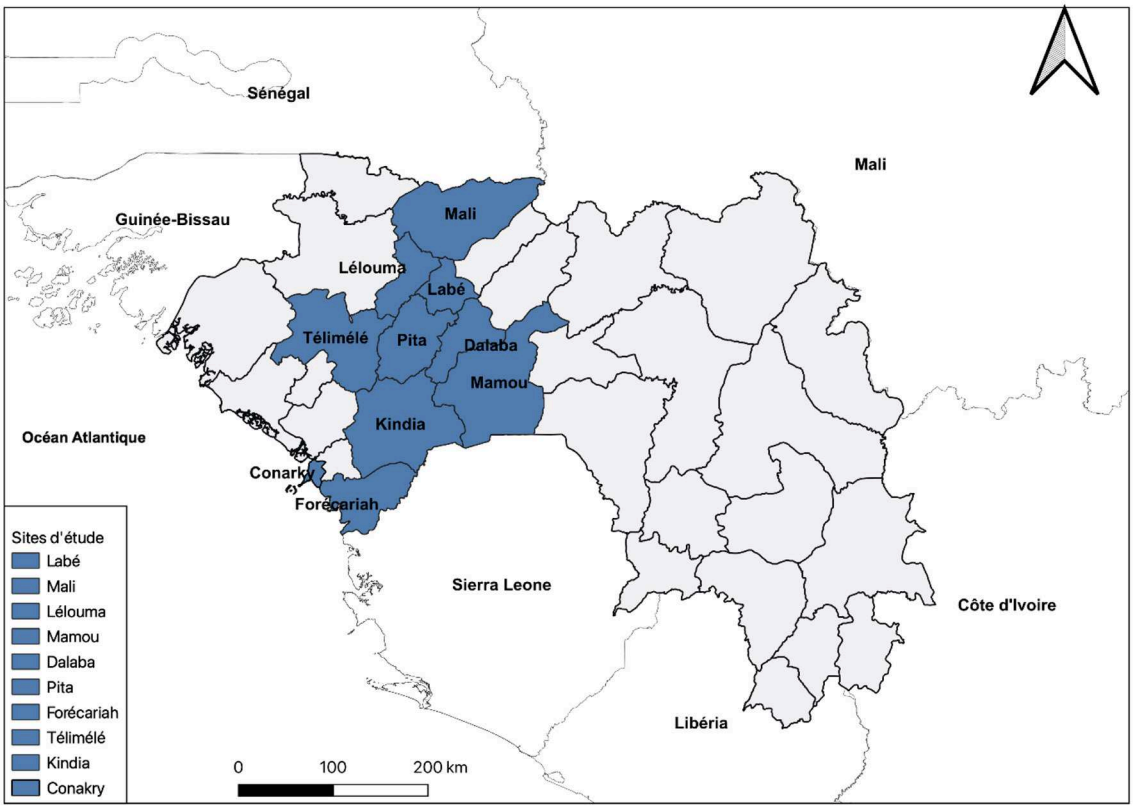

FIGURE 1
Health districts in the region of Kindia, Mamou, Labé and Conakry, Guinea, included in the study.

a multidisciplinary team (composed of two doctors and a sociologist) previously trained in data collection tools. Data collection took place over a period of three (3) weeks, from January 23 to February 11, 2022.

Data management and analysis

We processed and tabulated the data using Microsoft Office Suite Excel, and then analyzed using Stata version 16 software (Stata Corporation, College Station, TX, United States). Data for each indicator were clustered into a panel for exploitation.

outine data from March 2019 to December 2021 from the 41 facilities were collected over the same period and these quantitative data were described using proportions with their 95% confidence intervals. Trends in indicators before COVID-19 and during COVID-19 and during intervention were estimated by component using interrupted series analysis, as appropriate. We used segmented regression to measure changes in level and trend that followed the occurrence of COVID-19 and the intervention. Conveniently, we referred to Linden et al. (14) paper, which presents the itsa command and the effect of an intervention on an outcome variable for a given period.The Itsa (Interrupted time-series analysis for single and multiple groups with multiple panels) command on Stata was used to estimate the causal effect of the pandemic on a potential decline in health service use. The Itsa method therefore compares the finding that would have been by extrapolating the trend line of the finding of the period before the pandemic, as if it had never happened. Itsa uses ordinary least squares (OLS) and its use assumes that the observation point data are reported as panel data.

A modeling approach was used to assess how the average number of users of each healthcare facility changed immediately after the first COVID-19 cases were recorded, i.e., in March 2020, but also from the start of the project interventions, i.e., in April 2021 (change in level) and gradually over time (change in slope). The data were grouped by type of facility: private (associative health centers and community medical cabinets) and governmental (health centers and hospitals) in the four regions of the intervention areas. To facilitate the analysis, this regression model was used for each indicator: $Yt = \beta_0 + \beta_1 T_t + \beta_2 X_t + \beta_3 X_t T_t + \in_t$, where β0 represents the intercept or intercept or initial level, β1 is the change in the variable of interest (Yt) for 1 unit time, β2 represents the immediate change in Yt following the intervention, β3 represents the change in

the trend of Yt before COVID-19 relative to the trend before intervention (change over time) εt the error term:

The data from this matrix were grouped according to their similarity and difference and then described to assess the level of compliance with infection prevention and control measures in the health facilities.

Ethical considerations

The research protocol for this study was approved by the National Health Research Ethics Committee of Guinea (number L-080-CNERS-21) before the start of data collection. Then, an authorization had been obtained at the level of the health facilities before the beginning of the data collection including aspect of confidentiality.

Findings

Infection prevention and control practices of health care providers

The observation of the internal and external work environment showed that 100% of the community medical cabinets (CMCs), 95.2% of the associative health centers (AHCs) and health centers (HCs) were clean. In contrast, only 33.3% of hospitals (HP) had a clean internal and external environment. Analysis of the observation data revealed the existence of sorting areas in 83.3% of the HCs, 72.7% of the CMCs and 66.7% of the hospitals, compared with 57.1% of the AHCs.

It was found that hand washing devices at the entrance of the facilities were functional in 83.3% of the HCs, 72.7% of the CMCs, 66.7% of the AHCs and 33.3% of the hospitals. According to the results of the observations made, hand washing of visitors before admission to the facilities was systematic in the CMCs and HPs. However, 28.6% of the visitors in AHCs did not wash their hands before admission to the facility.

Temperature taking for visitors was not done in all the CMCs visited (100%) and in 90.5% of the AHCs; unlike in the HC and HP where the temperature of each patient was taken before entering the consultation room.

In addition, all health care providers observed in hospitals and HCs respected the mandatory wearing of masks compared to those in CMCs (36.4%) and AHCs (19%). The observation revealed that physical distancing in the waiting rooms and between users was not respected in all the facilities visited.

There was a waste sorting mechanism in all the hospitals visited, compared to 83.3%, 81% and 72% of the HC, AHC and CMC, respectively. It should be noted that in the prefectural hospital of Pita, empty cartons were used instead of safety boxes, which had been out of order for several months. Open burning of waste occurred in 52.4% of the AHCs. Lack of running water was observed in 54.5% of CMCs and 14.3% of AHCs (Table 1).

Use of maternal health services before COVID-19, before and after intervention

The interrupted series analysis approach used allowed us to highlight the trend in the use of maternal health services in the pre-COVID-19 period, before and during interventions in the intra-COVID-19 period. In all, the data collected covered 34 months: 12 months for the pre-COVID-19 period (March 2019-February 2020); 13 months for the intra-COVID-19 period (March 2020-March 2021) and before the interventions; and 9 months for the intra-COVID-19 period and during the intervention (April 2021-December 2021).

First antenatal care visit (ANC1)

As soon as the first COVID-19 cases were reported in March 2020, a drastic decline in ANC1 service utilization was observed in the associative health centers [$\beta = -702$; 95% CI = (-885; -520); $p = 0.001$] and the HCs [$\beta = -64$; 95% CI = (-137; 9); $p = 0.082$], while no changes were observed in the CMC. At the beginning of the project interventions in April 2021, this decrease continued in the AHCs, in contrast to the CMCs which experienced a significant increase of an average of 17 ANC1 per month [$\beta = 17$; 95% CI = (-3; 31); $p = 0.021$] similarly to the HCs where we saw an increase in the monthly average with 116 ANC1 [$\beta = 116$; 95% CI = (52; 180); $p = 0.001$] (Figure 2).

A Comparison of the pre-COVID-19 period to the intervention period showed a statistically significant increase in the average monthly number of ANC1 in AHCs and HCs in contrast to CMCs where it was zero (Table 2).

Fourth antenatal care visit (ANC4)

Upon reporting of the first COVID-19 cases in March 2020, a drastic decrease in ANC4 service utilization was observed in AHCs [$\beta = -1{,}015$; 95% CI = (-1,146;-883); $p = 0$; 001] and HCs [$\beta = -794$; 95% CI = (-909; 678); $p = 0.001$], while it remained virtually unchanged in the CMC. At the start of the project interventions in April 2021, an increase in the average monthly number of 60 (ANC4) was observed in both AHCs and CMC, in contrast to HCs where ANC4 utilization continued to decline. However, this increase was not statistically significant (Figure 3).

A Comparison of the pre-COVID-19 period to the intervention period showed a non-significant increase in the

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TABLE 1 Analysis of the observation matrix for the application of the IPC's on health structures. June 2022.

Application of IPC measures	Associative health centers		Community medical Cabinets		Government health centers		Hospitals	
	N	%	*N*	%	*N*	%	N	%
Hygiene of health facilities								
Is the external and internal environment of the facility clean?								
Yes	20	95.2	11	100	20	95.2	1	33.3
No	1	4.8	0	0	1	4.8	2	66.7
Is there a functional hand washing device at the entrance to the facility?								
Yes	14	66.7	8	72.7	5	83.3	1	33.3
No	7	33.3	3	27.3	1	16.7	2	66.7
Do providers respect hand washing between procedures?								
Yes	12	57.1	7	63.6	6	100	1	33.3
No	9	42.9	4	36.4	0	0	2	66.7
Do all visitors wash their hands before entering the center?								
Yes	6	28.6	8	72.7	6	100	3	100
No	15	71.4	3	27.3	0	0	0	0
Is there a tap water supply in the structure?								
Yes	18	85.7	5	45.5	6	100	3	100
No	3	14.3	6	54.5	0	0	0	0
Do providers wash their hands properly according to the guidelines?								
Yes	6	28.6	8	72.7	6	100	3	100
No	15	71.4	3	27.3	0	0	0	0
Wearing a ring on the fingers								
Yes	5	23.8	0	0	0	0	3	100
No	16	76.2	11	100	6	100	0	0
Presence of fingernails								
Yes	2	9.5	0	0	0	0	3	100
No	19	90.5	11	100	11	100	0	0
Is the waste area clean and tidy?								
Yes	16	76.2	9	81.8	6	100	3	100
No	5	23.8	2	18.2	0	0	0	0
Patient safety								
Is the temperature taken for all visitors to the center?								
Yes	2	9.5	0	0	6	100	3	100
No	19	90.5	11	100	0	0	0	0
Do the providers wear PPE correctly (Blouses, masks, gloves)?								
Yes	7	33.3	9	81.8	6	100	2	66.7
No	14	66.7	2	18.2	0	0	1	33.3
Do providers and users respect the mandatory wearing of masks?								
Yes	4	19.0	7	63.6	6	100	3	100
No	17	81.0	4	36.4	0	0	0	0
Is physical distance respected in the waiting rooms between users?								
Yes	5	23.8	4	36.4	0	0	0	0
No	16	76.2	7	63.6	6	100	3	100
Is physical distance maintained in the consultation and care offices between providers?								
Yes	16	76.2	8	72.7	6	100	2	66.7
No	5	23.8	3	27.3	0	0	1	33.3
The waste is buried or incinerated and not burned in the open air?								
Yes	10	47.6	10	90.9	6	100	3	100
No	11	52.4	1	9.1	0	0	0	0

(Continued)

TABLE 1 (Continued)

Application of IPC measures	Associative health centers		Community medical Cabinets		Government health centers		Hospitals	
	N	%	*N*	%	*N*	%	N	%
There are trash cans and safety boxes in all areas where waste is produced?								
Yes	17	81.0	8	72.7	5	83.3	3	100
No	4	19.0	3	27.3	1	16.7	0	0
The trash cans are well labeled and the waste segregation is respected?								
Yes	9	42.9	9	81.8	4	66.7	3	100
No	12	57.1	2	18.2	2	18.2	0	0
Is there a triage area in the facility for incoming patients?								
Yes	12	57.1	8	72.7	5	83.3	2	66.7
No	9	42.9	3	27.3	1	16.7	1	33.3

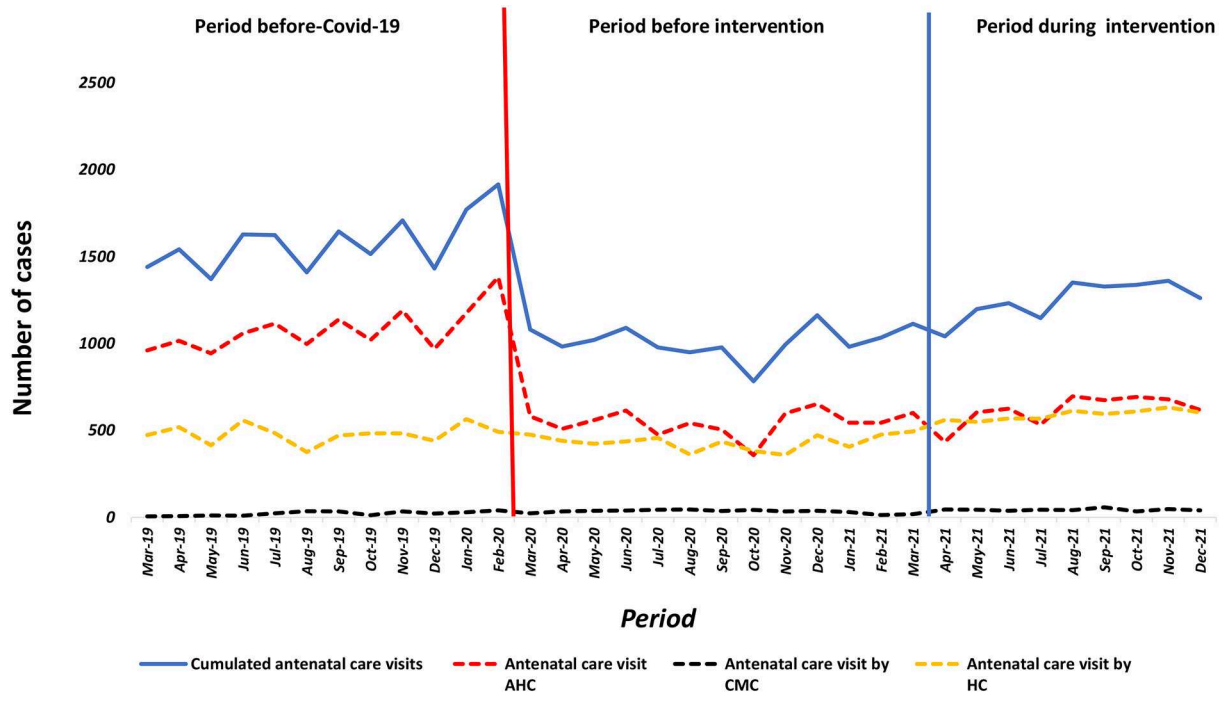

FIGURE 2
Number of women receiving one antenatal AHC, CMC, HC Guinea from March, 2019 to December, 2021.

average monthly number of ANCs4 in AHCs and HSs in contrast to CMCs where the decrease persisted (Table 3).

Institutional deliveries

As soon as the first COVID-19 cases were reported in March 2020, a drastic and significant decrease in the number of institutional deliveries was observed in AHCs [β = −596; 95% CI = (-677;−516); $p = 0.001$]. It also relatively decreased in CMCs [β = −13; 95% CI = (-28; 1); $p = 0.066$] and HPs [β = −4; 95% CI = (-135;−36); $p = 0.001$] in contrast to HCs where it relatively increased (Figure 4). At the beginning of the interventions in April 2021 in the AHCs experienced a significant increase of 87 institutional deliveries on average [β = 87; 95% CI = (15; 160); $p = 0.020$], as did the CMCs where on average an increase of 11 deliveries was noted [β = 11; 95% CI = (2; 20); $p = 0.014$], as well as 105 at the HCs [β = 105; 95% CI = (40; 171); $p = 0.003$], unlike the hospitals where no significant change was seen (Table 4).

TABLE 2 Estimates of parameters for monthly utilization of first antenatal visits. AHC, CMC, HC, Guinea. June 2022.

First antenatal visits

Variables	Private facilities						Governmental facilities		
	AHC			CMC			HC		
	Coef	95%	*P* value	Coef	95%	*P* value	Coef	95%	*P* value
Health service coverage at the beginning of the pre-COVID-19 period (β0)	950	877; 1,024	0, 000	8	2; 14	0, 010	470	411; 530	0, 000
Average monthly change in service coverage during the pre-COVID-19 period (β1)	24	4; 43	0, 018	3	2; 4	0, 000	2	−7; 10	0, 667
Immediate change in service coverage level at the start of COVID-19 (β2)	−702	−885;−520	0, 000	0	−15; 15	0, 988	−64	−137; 9	0, 082
Difference between the trend in service coverage during COVID-19 and the pre-COVID-19 period (β3)	−21	−42;−1	0, 044	−4	−6;−2	0, 001	−1	−12; 10	0, 861
Immediate change in service coverage level at the start of the INTERVENTION (β2)	−25	−156; 105	0, 694	17	3; 31	0, 021	116	52; 180	0, 001
Difference between the trend in service coverage during the INTERVENTION and the period prior to COVID-19 (β3)	18	−4; 41	0, 104	1	−1; 3	0, 318	8	0; 16	0, 054
Total									
Linear trend before COVID-19 and during INTERVENTION	21	0; 41	0, 054	0	−1; 1	0, 909	9	5; 13	0, 000

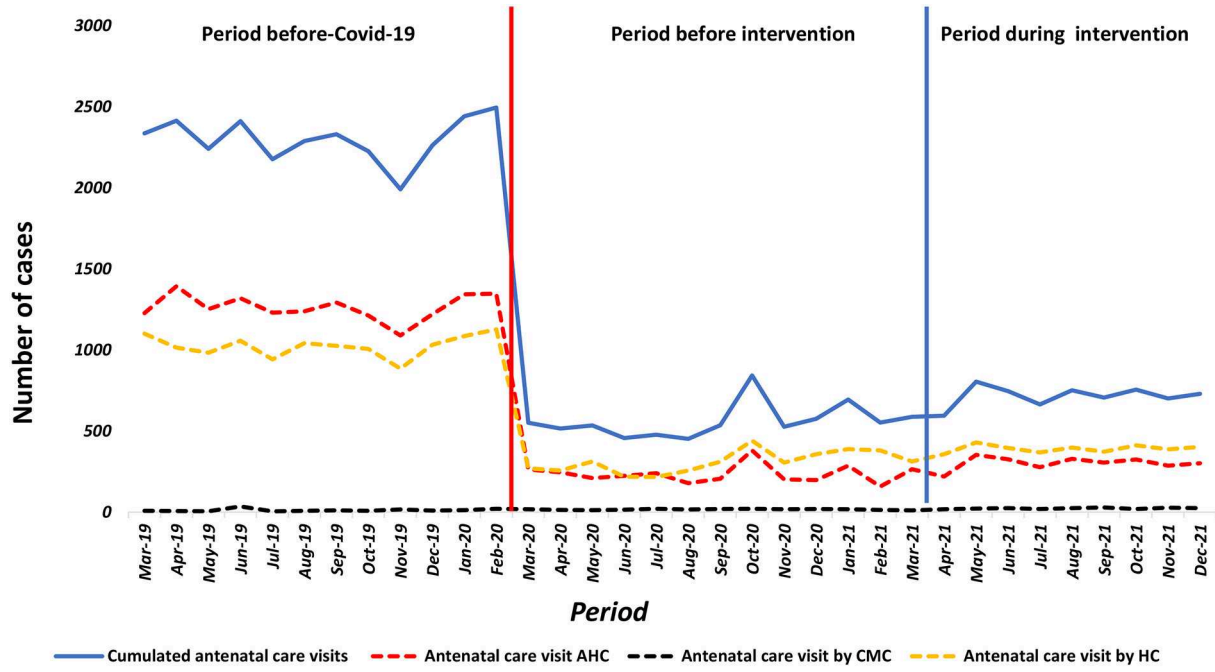

FIGURE 3
Number of women receiving four antenatal AHC, CMC, HC Guinea from March, 2019 to December, 2021.

TABLE 3 Estimates of parameters for the monthly use of fourth antenatal visits. AHC, CMC, HC, Guinea. June 2022.

Fourth antenatal visits

Variables	Private facilities						Governmental facilities		
	AHC			CMC			HC		
	Coef	95%	*P* value	Coef	95%	*P* value	Coef	95%	*P* value
Health service coverage at the beginning of the pre-COVID-19 period (β0)	1,274	1,186; 1,361	0, 000	10	−1; 20	0, 074	1,013	941; 1,086	0, 000
Average monthly change in service coverage during the pre-COVID-19 period (β1)	−2	−18; 14	0, 819	0	−1; 2	0, 397	2	−11; 15	0, 749
Immediate change in service coverage level at the start of COVID-19 (β2)	−1,015	−1,146;−883	0, 000	1	−5; 8	0, 685	−794	−909;−678	0, 000
Difference between the trend in service coverage during COVID-19 and the preCOVID-19 period (β3)	1	−16; 19	0, 871	−1	−2; 1	0, 396	9	−6; 24	0, 236
Immediate change in service coverage level at the start of COVID-19 (β2)	60	−46; 166	0, 256	4	−1; 10	0, 131	−1	−73; 71	0, 985
Difference between the trend in service coverage during the INTERVENTION and the pre-COVID-19 period (β3)	3	−12; 18	0, 688	1	0; 2	0, 142	−9	−19; 0	0, 057
Linear trend before COVID-19 and during INTERVENTION (b1+ b3)	3	−11; 16	0, 696	1	0; 1	0, 095	11	4; 18	0, 003

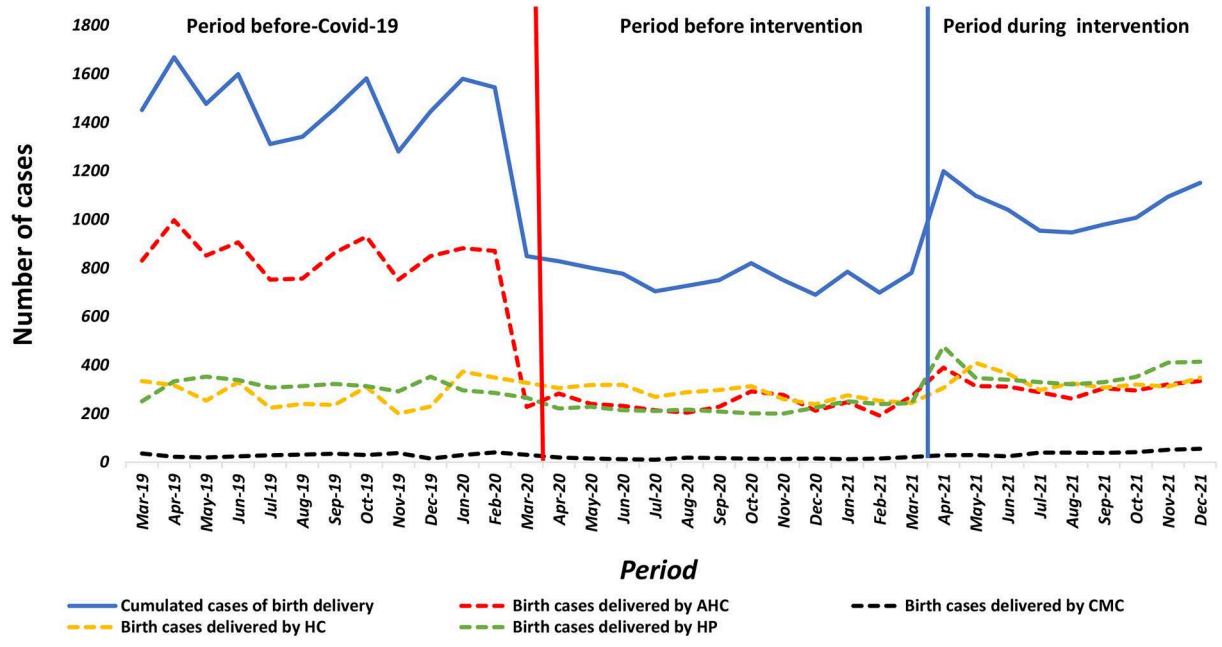

FIGURE 4
Number of women giving birth in the health facility AHC, CMC, HC Guinea from March, 2019 to December, 2021.

TABLE 4 Estimates of parameters for monthly utilization in institutional delivery services. AHC, CMC, HC, HP Guinea. June 2022.

Institutional deliveries												
	Private facilities						Governmental Facilities					
Variables	AHC			CMC			HC			HP		
	Coef	95%	*P* value	Coef	95%	*P* value	Coef	95%	*P* value	Coef	95%	*P* value
Health service coverage at the beginning of the pre-COVID-19 period (β0)	868	775; 961	0, 000	26	17; 35	0, 000	281	223; 340	0, 000	13	266; 366	0, 000
Average monthly change in service coverage during the pre-COVID-19 period (β1)	−3	−15; 9	0, 657	1	−1; 2	0, 495	0	−11; 12	0, 951	0	−8; 6	0, 867
Immediate change in service coverage level at the start of COVID-19 (β2)	−596	−677;−516	0, 000	−13	−28; 1	0, 066	38	−56; 133	0, 413	−4	−135;−36	0, 001
Difference between the trend in service coverage during COVID-19 and the preCOVID-19 period (β3)	3	−10; 16	0, 685	−1	−3; 1	0, 317	−7	−18; 5	0, 236	0	−7;9	0, 833
Immediate change in service coverage level at the start of COVID-19 (β2)	87	15; 160	0, 020	11	2; 20	0, 014	105	40; 171	0, 003	3	45; 245	0, 006
Difference between the trend in service coverage during the INTERVENTION and the pre-COVID-19 period (β3)	−4	−16; 9	0, 555	4	2; 5	0, 000	3	−8; 14	0, 582	0	−20; 18	0, 926
Total												
Linear trend before COVID-19 and during intervention	−4	−15; 7	0, 514	3	2; 4	0, 000	−3	−14; 8	0, 532	0	−19; 18	0, 946

Discussion

To our knowledge, this study is the first of its kind to analyze health care providers' practice of infection prevention and control (IPC) and maternal health service utilization during the COVID-19 pandemic in Guinea. Our study shows mitigated results of health care providers' practice with respect to the application of IPC measures. For example, almost all health care providers observed in hospitals and health centers complied with the mandatory wearing of facemasks and the systematic recording of temperatures of visitors attending the health facilities. In contrast, in community health cabinets (CMCs) and associative health centers (AHCs), more than six out of 10 health providers did not respect the mandatory wearing of a facemask. In addition, the systematic measurement of temperature was not observed among visitors attending community health cabinets (CMCs) and associative health centers (AHCs). A plausible explanation for these results would be the limited number of financial sources and actors involved in the supply of personal protective equipment, including facemasks in these health facilities. Indeed, the two types of health facilities concerned are all privately owned, which would limit the intervention of state actors and other organizations in the supply of personal protective equipment. Another important explanation for the results of this study could be that the project implementers did not take into account equity in the supply of health facilities. Indeed, the practical experience of implementing the "Strengthening the health system to ensure continuity of services and access to care for vulnerable populations in the COVID-19 context" project shows that the health facilities involved in the project were provisioned only for a few months. This inconsistent allocation of health commodities would certainly not have enabled the private health facilities to prevent input shortages. Ashinyo, et al. (15) in Ghana observed low compliance by health care providers with the use of personal protective equipment in health facilities reporting frequent input shortages. The low compliance of health care providers with regard to visitors' temperature recording could be explained by their low perception of the risk of disease transmission during the data collection period. In fact, the data collection period for this study (January-February 2022) did not correspond to a period of high intensity of COVID-19 transmission in Guinea (16). Huang et al. (17) in their longitudinal study of health care providers' behavior in France reported a reduction in healthcare providers' compliance with infection prevention and control measures during periods when containment was lifted and transmission was low. In view of these results, we recommend that the actors of this particular project, and the actors of the health system in general, take into account, in future projects, the equity of supply of inputs between public

and private health structures, but also to favor periodic (monthly or semi-annual) allocation of inputs instead of temporal or single allocation.

Another mitigated result of this study is that more than half (52.4%) of the AHCs burned their waste in the open air compared to other types of health facilities that incinerated their waste. Similarly, more than four out of 10 community health cabinets did not have patients' separation or sorting areas. In our experience, the community health cabinets, all of which are located in the Conakry region, are the result of the transformation of human dwellings; therefore, they often do not meet the standards of health facilities in terms of space and location. For example, most of the community health cabinets visited during the data collection did not have space for incinerators for waste management, nor they did for patient sorting areas. The absence of sorting areas in all of the ASCs raises questions about how these health facilities proceed during the COVID-19 pandemic. Taking into account the recurrence of diseases with epidemic potential in Guinea, one might question the capacity of these health facilities to offer safe health care to the population (17). The other question about the safety of the care offered in the AHCs, given their location, particularly their proximity to people's homes, is the practice of burning waste in the open air in some of these facilities. Indeed, the probability of these health facilities practicing open burning of biomedical waste to release pathogenic bacteria and toxic gases into their environment would be high (18, 19). These results point to the need for health system actors to support associative health centers in obtaining appropriate space for their establishment, in order to ensure safe health care delivery during epidemics (patient sorting areas) as well as safe management of biomedical waste from these health structures.

Our analysis showed an increase in maternal health service utilization levels during the project intervention, compared to the pre-intervention period. However, these utilization levels during the project intervention period remained below pre-COVID-19 levels. These results are superimposed on the 2017 study by Delamou, et al. (5). after the Ebola outbreak in Guinea; the authors reported low levels of maternal health service utilization 12 months after the Ebola outbreak, compared with the pre-Ebola period. A key question to ask is why maternal health indicators are struggling to recover to pre-COVID-19 levels despite low lethality. These results raise questions about the resilience of the national health system, particularly the ability of health services to recover a few moments after the occurrence of epidemics (20–22). Critical analysis of health service utilization levels during the project intervention period, compared to pre-COVID-19 levels, suggests that the project's objectives were only partially achieved. One possible explanation for this finding is the delay in the provision and delivery of project inputs to beneficiary health facilities. Indeed, it was noted during data collection that some health facilities had not yet been provided with medical kits and materials. Finally, our data show that the levels of increase in maternal health services varied according to the type of health facility and the maternal health indicators covered by our study. For example, ANC4 utilization levels remained almost unchanged during the project intervention period compared to the pre-intervention period in all types of health facilities included in our study. However, levels of utilization of health services for childbirth increased statistically significantly during the intervention period, compared to the pre-intervention period, in primary health facilities (AHC, CMC, and HC). In contrast, hospitals did not experience a statistically significant increase in the level of deliveries. The increase in the level of utilization of delivery services in all primary health facilities, compared to the level of utilization of ANC4 services, could be explained by the offering of incentives such as buckets, soaps, and newborn clothes to women delivering in the health facilities. However, the small change in the level of utilization of delivery services in hospitals would be related to the low use of pregnant women in these facilities dedicated to receiving complicated cases of childbirth.

Limitations

A limitation of this study is that due to the methodological approach used in our study, it was difficult to link changes in the levels of use of maternal health indicators during the period of the project interventions to the interventions.

Conclusion

This study revealed a slight increase in the demand for maternal health services, which could be explained by the provision of equipment and delivery kits to support women giving birth in these health facilities. In addition, a lack of infection prevention and control measures in health centers, particularly those run by associations (AHC), has been observed. It is therefore necessary to ensure that infection prevention and control measures are respected, but also that sorting areas for patients and waste disposal circuits are set up in these different structures.

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.

Ethics statement

The studies involving human participants were reviewed and approved by National Ethics and Health Research Committee of Guinea. Written informed consent for participation was not required for this study in accordance with the national legislation and the institutional requirements.

Author contributions

The study protocol was developed by MK and LB and reviewed by WD, SS, and AD. The data were analyzed by MK and DK. The first draft of the manuscript was written by MK and LB and critically reviewed by WD, JD, SS, and AD. All authors participated in the interpretation, read and approved the final version of this manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

The reviewer KK declared a shared affiliation with four of the authors to the handling editor at the time of the review.

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Evaluating and rethinking public health for the 21st century: Toward vulnerable population interventions

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Introduction

Public health preventive interventions aim to improve population health through two main approaches. Firstly, individual-centered interventions seek to change knowledge and behaviors of individuals identified as at high risk of disease. Secondly, population-centered interventions are delivered across the whole population, without prior detection of individuals at increased risk of disease (1). Population-centered interventions can address three types of health determinants: (i) the personal behaviors (e.g., mass media campaigns to improve diet), (ii) the physical environment (e.g., clean air and water policies), and (iii) the social and economic environment (e.g., safe housing provision). Despite the significant role of both individual- and population-centered approaches in improving population health during the last decades, health inequities between socially, culturally, or financially disadvantaged groups within populations are increasing, at least for some health outcomes (2). This is partly due to shortcomings of both individual- and population-centered approaches. Learning from modern public health history and given the health emergencies such as the COVID-19 pandemic, this commentary argues that 21st-century public health should mainly invest in vulnerable population interventions. This approach aims to decrease health inequities between socially defined groups and is a necessary complement to population-centered interventions.

Learning from the history: Shortcomings of the individual- and population-approaches

In the late 18th and 19th centuries, public health concentrated its efforts on improving sanitation and preventing communicable diseases using population-centered interventions (e.g., safe sewage disposal and mass vaccinations), which led to massive

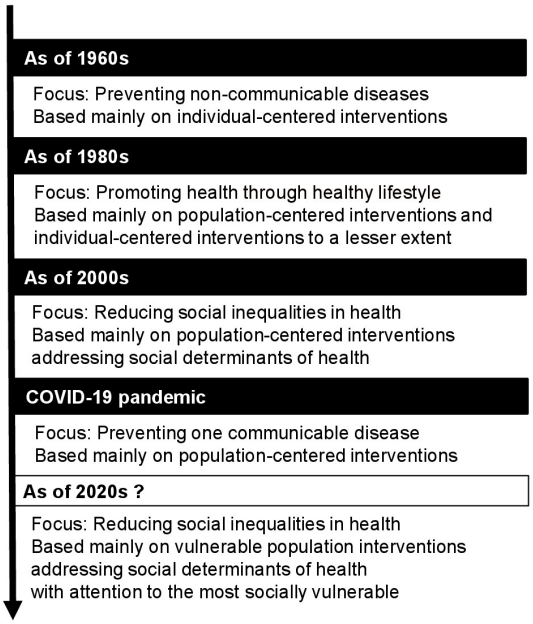

FIGURE 1
Overview of the modern history of preventive public health and its desirable future.

improvements in population health (3). For instance, in the United States, life expectancy at birth increased from <44 years in 1890 to more than 70 years in 1965 (79 years in 2020) (4). After the Second World War (Figure 1), non-communicable diseases (NCDs, e.g., cardiovascular disease, cancers) took over communicable diseases as the leading cause of death. Preventive public health interventions were primarily based on disseminating information to high-risk individuals regarding the risk of newly identified unhealthy behaviors (e.g., tobacco smoking, poor eating habits, low physical activity) (1).

The impact of this individual-centered approach to preventing NCDs was limited (1). An emblematic example was the Multiple Risk Factor Intervention Trial (MRFIT) involving 12,866 men at high risk of coronary heart disease (5). Despite intensive programs to decrease cardiovascular risk factors (i.e., stepped-care drug treatment for hypertension, smoking cessation program, fat-modified diet, and weight control when necessary), no significant differences in mortality rates were found between the intervention and control groups after seven years of follow-up (5).

One of the main critiques of individual-centered approaches has been its emphasis on framing the problem as one of personal responsibility. Providing psychoeducational health counseling regarding individual behavior modifications has been deemed insufficient in the absence of societal changes conducive to these changes (1). A second critique by Geoffrey Rose in the 1980s was that "a large number of people at a small risk may give rise to more cases of disease than the small number who are at a high risk" (1). Of note, it has been previously discussed that even if these approaches reduce the risk of those targeted, the persistence of the societal forces provides conditions for new people to enter the at-risk population (6).

Acknowledging that modifying individual behaviors without altering population-level life conditions is challenging and that lowering the mean level of risk (of disease) in everyone (rather than in high-risk individuals only) is more impactful, public health moved its focus away from disease prevention toward health promotion in the 1980s. Organized by the World Health Organization (WHO), the first International Conference on Health Promotion in 1986 in Ottawa established a Charter to achieve Health for all by the year 2000 and beyond. The Ottawa Charter represented a milestone for health promotion and stressed the critical role of environments, community, and public policy in promoting health in various sectors, such as legislation and fiscal measures (7). The Charter also defined health as "a resource for everyday life, and not the objective of living" and highlighted the importance of "enabling people to increase control over, and to improve, their health" (7). Health promotion concentrates on creating collective capacities for living mainly with population-centered interventions (e.g., smoking-free public spaces) rather than preventing disease at the individual level (e.g., smoking cessation programs).

Despite successes in the prevention and control of NCDs in different parts of the world through a variety of population-based interventions (e.g., smoke-free space, cigarette excise tax increase, tax on sugar-sweetened beverages), population-centered interventions have not accomplished their full potential. In the early 21st century, some public health experts noted the neglect of socially vulnerable groups (e.g., racial and ethnic minorities; socioeconomically disadvantaged groups) (6). For instance, population-level smoking rates have reduced, but social inequities in smoking have grown (8). These experts notably pointed out that population-centered approaches that address personal health behaviors and not the contextual conditions (fundamental causes) tend to widen social inequities in health (6). Indeed, less vulnerable individuals derive more benefits from the interventions than the most vulnerable, arguably due to the financial, cultural, and social resources available to each group (9, 10). For instance, women with higher incomes were more likely to be screened for cervical cancer screening than those with lower incomes in Ontario and the United States (11). Another example is the public information campaign for folate intake in women of childbearing age, which tended to be most effective among women with higher education (12).

In 2008, social inequities in health featured prominently in the WHO's report "Closing the Gap in a Generation: Health Equity Through Action on the Social Determinant of Health," reflecting their global salience (2). This report called for health equity and argued that public health should focus on the social

determinants of health, including gender, ethnicity, education, income (distribution), working conditions, access to sufficient healthy food, and housing (2). To achieve that, public (health) interventions should change the systems and organizations that shape the circumstances in which people grow, live, work, and age (2).

Then, in 2020, with the COVID-19 pandemic, population-centered interventions, such as social distancing, quarantine, mask-wearing, workplace closure, and vaccinations, have taken a front and center place. These population-centered interventions did not focus on social determinants of health, and as expected, benefits were limited among the most socially vulnerable. The latter were more exposed to the virus and were more likely to fall ill, die, and end up with long-haul COVID-19, further exacerbating health inequities (13, 14). Given the substantial inequities in COVID-19 and its outcome, few initiatives started focusing on vulnerable communities (e.g., the United States National Initiative to address COVID-19 health disparities among populations at high-risk and underserved, including racial and ethnic minority populations and rural communities) (15). However, these deliberate efforts are far behind the initial population-based efforts. The COVID-19 pandemic has thus highlighted again that socially vulnerable groups require different kinds of interventions.

Future directions for preventive public health: Vulnerable population interventions

After the COVID-19 crisis and given other health emergencies such as climate change, it is the perfect time to rethink public health. Public health needs more vulnerable population interventions so that socially vulnerable groups are not left behind. If the past is any guide, future public (health) interventions should be population-centered and address the social determinants of health. Examples of these types of interventions are increased childcare institutions, strong and equal education systems, subsidized healthy school meals, safe housing provision, and a psychologically safe workplace. In addition, and according to the local needs, these population-centered interventions should be complemented with interventions targeted to the most socially vulnerable groups (6). Defined with local communities, these participatory interventions can be related to, for example, early childhood development programs, groceries with free foods, peer-support programs to quit smoking, and health literacy programs.

In the 21st century, preventive public health should invest more in a vulnerable population approach, i.e., population-centered interventions addressing the social determinants of health and combined with community-based participatory interventions when and where needed (6). This vulnerable population approach is the most likely to reduce health inequities and improve population health in the long term.

Author contributions

AC and SK-S: conceptualization, writing—original draft, review, and editing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Investigating a key structural determinant of health, racism, and related social determinants of health in Massachusetts during the COVID-19 pandemic

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A disproportionate burden of the ongoing COVID-19 pandemic is being shouldered by members of racial and ethnic minorities and socially disadvantaged communities. Structural and social determinants of health have been recognized as key contributors to the inequalities observed. Racism, a major structural determinant of health that patterns related social determinants of health, in the USA, warrants further investigation. In this perspective piece we provide an overview of the historical context of racism, followed by preliminary findings from the ongoing COVIDStory study—a cross-sectional study addressing perceptions of COVID-19 and COVID-19 research—that highlights the experiences of non-Hispanic Black and Hispanic identifying adult participants, residing in Worcester Massachusetts, during the COVID-19 pandemic. We then discuss these findings in the context of current and past research considering racism and relevant social determinants of health. Our study results suggest that racism and its residuals (residential segregation, economic insecurity, discrimination, bias, and vigilance) are modern challenges for non-Hispanic Black and Hispanic participants, and these findings are supported by the existing literature. It is our hope that this perspective piece provides additional evidence for action on structural and social determinants affecting the health of minoritized people, especially those living in Massachusetts.

KEYWORDS

SDOH, racism, structural determinants, COVID-19, Massachusetts

Introduction

It is widely recognized that structural and social conditions substantially impact health outcomes (1). The ongoing COVID-19 pandemic is no exception, as many stark disparities, such as in mortality, disease severity, and hospitalization, have been linked to social determinants of health (SDOH). SDOH are the environments where people are born, live, work, play, worship, and age (2). The relationships between SDOH and the disproportionate burden of the COVID-19 pandemic on racial and ethnic minorities and socially disadvantaged groups have been explored both in Massachusetts (3–5) and around the nation (6, 7). Less emphasized, but equally as important, are the structural determinants of health that influence the distribution of SDOH (e.g., current and historical policies that shape the pattern of social determinants in populations, institutions, and cultural norms) (8).

This paper highlights the importance of understanding and mitigating structural determinants as a means to begin equalizing SDOH in the context of the COVID-19 pandemic. We focus on the most pervasive structural determinant—racism (Figure 1). We begin by discussing the historical context of racism that shapes SDOH, we will then present preliminary descriptive data ($n = 166$) on SDOH (patterned by racism) from the COVIDStory study followed by discussions of specific SDOHs that are patterned by racism and contribute to inequality in SARS-CoV-2 transmission, morbidity, and mortality in Massachusetts. By presenting our perspective, grounded in data and an investigation of racism as a primary structural determinant, we hope to present new insights in support of action toward dismantling barriers and achieving health equity for racial and ethnic minorities.

Historical context

One cannot fully understand and address the inequalities in American health outcomes without considering the long-lasting impacts of the United States' history. At the nation's establishment, early settlers endeavored to maintain an economy based on enslaved labor, though purporting to prioritize and uphold the rights of all "men" (9). The contradiction between the latter and legally enforced enslavement was resolved by deeming some less human. This resulted in continued systemic inequalities following emancipation (9). People of color, especially those of African descent, were placed on the lower rungs of a contrived and baseless racial ladder, which was used to justify the maintenance of widespread, oppressive systems and influenced social relations, structures, and science (9, 10).

Despite many early unjust laws and policies being formally dismantled and racial taxonomies scientifically discredited, inadequate acknowledgment, address, and remediation have led to the transformation and institutionalization of racism (9, 10). Early examples can be seen in two of Massachusetts's largest cities, Boston and Worcester. While African Americans were not legally prohibited from attending schools in the 18th and 19th centuries, unofficial bans existed. By 1830, African American abolitionists began working with White abolitionists to end segregation in schools, transportation, and other public spaces (11). Though Black persons moved to Worcester during a time of immense industrial growth—they were often only allowed to work low-skilled and low-waged jobs, earning less and therefore being at greater risk for entrapment in poverty and the adverse outcomes associated with inadequate income (9, 10, 12). This relegation, based on the early racialization of people of color, continues even after the introduction of civil rights laws in the 1960s (9–13). A clear example of this includes the passage of the Fair Housing Act in 1964, homeownership, the primary means of wealth building, which continues to be highly unequal along racial lines (14). The practice of redlining, created by the Homeowner's Loan Corporation, but used by the Federal Housing Administration, determined who would get mortgages to buy homes based on the demographics of the neighborhoods in which they wanted to live. So-called "red" areas were those with Black residents, and, to a lesser extent, migrants and the working-class. Perhaps one of the most evident and long-lasting consequences of redlining, can be seen in the disinvestment in these neighborhoods, thus leading to current residential segregation, sustained economic inequalities, and unequal SDOH (15, 16).

Social determinants of health

The COVID-19 pandemic has exacerbated existing and historical inequities across the Commonwealth of Massachusetts (17). Neighborhoods and communities, historically under-resourced and disenfranchised, have been subject to unique exposures not encountered by other groups (17). Massachusetts leadership recognizes the importance of SDOH including residential segregation and neighborhood factors, economic insecurity, discrimination, and racial bias negatively impacting the health of its communities. However, the COVID-19 pandemic has generated a distinct and accelerated intersection of health circumstances, predisposing minoritized groups to high rates of SARS-CoV-2 transmission, COVID-19 disease severity, and mortality (18, 19). Inequitable systems, driven by racism and reinforced by factors such as adverse SDOH, have disproportionately burdened communities of color throughout the pandemic and compounded effects on racialized populations' adverse physical and mental health outcomes.

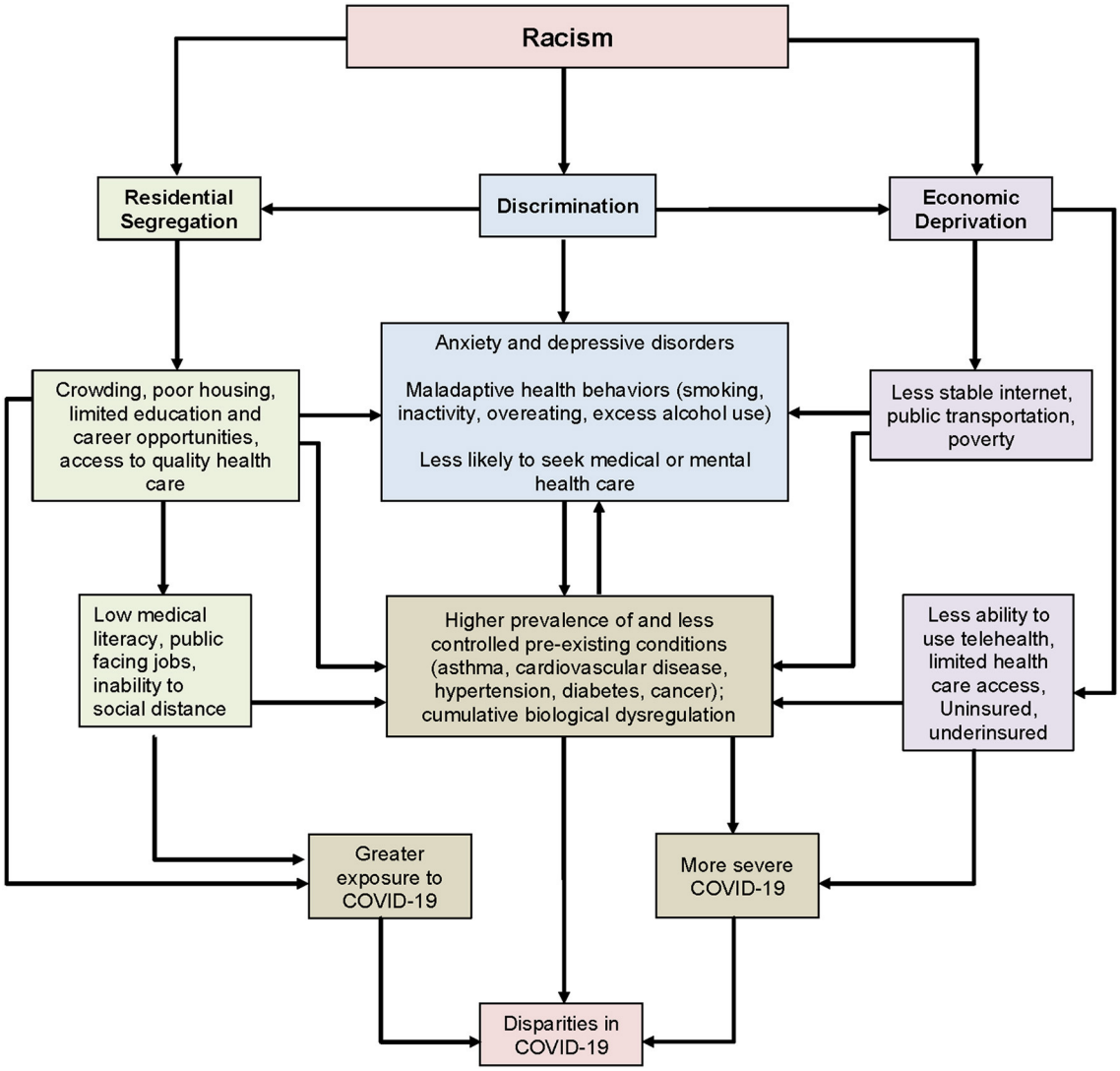

FIGURE 1
Conceptual model-Racism as root cause of disparities in COVID-19.

Methods

Study population

Survey and descriptive data were collected from an ongoing study to test a storytelling intervention to increase the participation of minoritized populations in Worcester, Massachusetts in SARS-CoV-2 antibody research. The data comes from a convenience sample ($n = 166$) of Worcester County, MA residents who identify as Black and/or Hispanic. Participants had to answer "yes" to identifying as Black or Hispanic, being over 18 years of age, and living in Worcester County. Informed consent was obtained, and the UMass Chan Medical School IRB approved the study protocols. Responses were collected between September 2021 and July 2022. (20).

Study variables and analysis

Table 1 presents study variables for our analyses. Residential segregation and neighborhood factors were measured by the zip code participants lived in the last week. Census bureau data for each zip code was obtained from data.census.gov. Economic insecurity was evaluated based on the relationship between reported income levels within an area of concentrated poverty. Finally, measures of Discrimination, Racial Bias, and Vigilance were investigated using a) the 10-item Everyday Discrimination Scale, b) 6-item Vigilance scale, and c) 9-item COVID Bias Scale. The Everyday Discrimination Scale (EDS) is employed by health disparities researchers to describe subjective experiences of daily discrimination against minoritized persons (21). The Vigilance scale is a 6-item

questionnaire assessing increased attentiveness in anticipation of victimization (22). The Coronavirus Racial Bias Scale (CRBS) is a 9-item questionnaire developed as part of the Pathways to Health Study (23) assessing participants' beliefs about how the COVID-19 pandemic negatively affects societal attitudes toward people of their racial/ethnic identity. All economic and COVID discrimination-related questions were used from the PhenX Toolkit COVID-19 Protocol Library. The EDS and Vigilance Scale were used from the Measuring Discrimination Resource (22, 24).

Participant sociodemographic characteristics were examined using descriptive statistics. Comparisons were made using *t*-test for continuous and chi-square test for categorical variables.

Preliminary findings

Residential segregation/neighborhood factors

Forty-two percent of participants identified as Black or African American, 71% identified as Hispanic/Latino (Table 2) and 65% identified as women. Two-thirds of participants indicated that they lived in Worcester City, and 52% lived in a zip code with concentrated poverty as defined by the Census Bureau (≥20% of residents living below the poverty threshold). Although the percent of Black and Hispanic residents of Massachusetts is 9.3 and 12.8%, respectively, among respondent zip codes with concentrated poverty, percentages of Black and Hispanic residents ranged from 6 to 25.2% and 18.2 to 49.5%, respectively.

Economic insecurity

The annual income of participants who lived in zip codes with concentrated poverty (Mean (M) = $38,000, Standard Deviation (SD) = $29,000) was significantly lower than for participants who did not live in zip codes with concentrated poverty (M = $60,000, SD = $40,000), t (134.5) = 3.7, $p < 0.001$. The mean income of the sample was about $49,000 (range = $ 0–$150,000). Sixty-nine percent of participants indicated that they had enough money to pay the bills pre-COVID and 21% indicated that they did not. However, 55% said that their household income decreased significantly since the pandemic began, 45% were very worried that the pandemic has negatively impacted their household income, and 53% were very worried that the pandemic has negatively affected the value of their assets. Fifty-five percent had low or very low food security at the time of the survey and 34% received food from a food pantry.

Discrimination, racial bias, and vigilance

Seventy-four percent of participants indicated that they had experienced discrimination at least once a year and of those who experienced discrimination, 61% attributed the discrimination to their race or skin color. Among those who indicated that they experienced discrimination, 26% said that they exhibited vigilance behaviors (e.g., thinking in advance about problems, prepare for insults) fairly often, very often, or always. Pertaining to COVID-19 specific bias and in reference to people of the respondent's race/ethnic groups, 44% agreed that the country is more dangerous; 62% agreed that they are more likely to lose their job; and 50% agreed that they would not receive healthcare as good as the care received by other groups.

Discussion

In this study, more than half of the participants lived in a zip code of concentrated poverty. More than 1 in 3 identified as Black or African American and more than 1 in 2 identified as Hispanic or Latino. Since the pandemic began, greater than half of participants stated that their household income significantly decreased, and more than half were reportedly food insecure. About 3 in 4 participants experienced discrimination, with a majority attributing that discrimination to their race or skin color, and a quarter very often, or more often, exhibited vigilant behaviors. This data on residential segregation and neighborhood factors, economic insecurity, and discrimination exemplifies the SDOH in a local context. While we did not investigate causality, these data supplement the growing body of evidence concerning racism and health disparities that were further magnified by the COVID-19 pandemic (15, 17, 19, 20).

Residential segregation/ neighborhood factors

The housing policies discussed in the Historical Context section continue to negatively affect the health and economic prospects of those shunted or confined to neighborhoods deemed undesirable. In this study, we observed that more than half of participants live in a zip code of concentrated poverty. Evidence shows that even before the pandemic, historical housing policies were associated with the health of residents in segregated and disinvested neighborhoods (25, 26). Physical separation of races into neighborhoods, or residential segregation, has repeatedly been shown to negatively affect the health of residents through concentrated poverty, limited access to quality care, and limited access to health-maintaining behaviors (e.g., fresh foods, physical activity) (27). These pre-existing barriers have resulted in a disproportionate impact of the COVID-19 pandemic on those who live in disadvantaged

TABLE 1 Study questions and variables for analysis.

Residential segregation/neighborhood factors
Do you identify as Hispanic or Latino?
What is your race?
What is your gender?
Do you consider yourself to be: heterosexual or straight, lesbian, gay, bisexual, other, prefer not to answer
Economic Insecurity
What was your combined annual household income (pretax); all sources in the past year?
How would you best describe your financial situation before COVID-19?
Has your household income changed significantly since COVID-19?
How worried are you that income will negatively be impacted by COVID-19?
How worried are you that your assets will be negatively impacted by COVID-19?
Since February 2020, have you either received, applied for, or tried to apply for any of the following forms of income or assistance: • A food pantry
In the last 12 months, the food that (I/we) bought just didn't last, and (I/we) didn't have money to get more: often true, sometimes true, never true, don't know
In the last 12 months, (I/we) couldn't afford to eat balanced meals: often true, sometimes true, never true, don't know
In the last 12 months, did (you or other adults in the household) ever cut the size of your meals or skip meals because there wasn't enough money for food?
In the last 12 months, did you ever eat less than you felt you should because there wasn't enough money to buy food?
In the last 12 months, were you ever hungry but didn't eat because you couldn't afford food?
Discrimination, Racial Bias, and Vigilance
You are treated with less courtesy than other people: never, less than once a year, a few times a year, a few times a month, at least once a week, almost every day
You receive poorer service than other people at restaurants and stores: never, less than once a year, a few times a year, a few times a month, at least once a week, almost every day
People act as if they think you are not smart: never, less than once a year, a few times a year, a few times a month, at least once a week, almost every day
You are called names or insulted: never, less than once a year, a few times a year, a few times a month, at least once a week, almost every day
You are threatened or harassed: never, less than once a year, a few times a year, a few times a month, at least once a week, almost every day
What do you think is the main reason for these experiences? (ancestry or national origins, race, sexual orientation, gender, some other aspect of your physical appearance, education level or income level, other)
How often do you think in advance about the kind of problems you are likely to encounter? (never, hardly ever, fairly often, very often, always)
How often do you try to prepare for possible insults before leaving your home? (never, hardly ever, fairly often, very often, always)
How often do you carefully watch what you say and how you say it? (never, hardly ever, fairly often, very often, always)
How often do you carefully observe what happens around you? (never, hardly ever, fairly often, very often, always)
How often do you try to avoid certain social situations and places? (never, hardly ever, fairly often, very often, always)
I believe the country has become more dangerous for people in my race and ethnicity: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
I worry about people thinking I have COVID simply because of my race/ethnicity: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
Most social and mass media reports about COVID create bias against people of my race/ethnicity: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
People of my race/ethnicity are more likely to get COVID: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
People of my race/ethnicity will not receive COVID healthcare as good as the care others receive: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
Due to COVID, I have been cyberbullied because of my race/ethnicity: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
Since COVID I have seen a lot more cyberbullying of people of my race/ethnicity: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
Negative social media posts against people of my race/ethnicity have increased: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)
People of my race/ethnicity are more likely to lose their job because of COVID: (strongly agree, somewhat agree, neither agree nor disagree, somewhat disagree, strongly disagree)

TABLE 2 Race and Ethnicity of COVIDStory Participants.

	Total % (*n*)	Hispanic/ Latino % (*n*)	Not Hispanic/ Latino % (*n*)
White	19% (31)	19% (31)	0
Black or African American	42% (70)	15% (25)	27% (44)
American Indian or Alaskan Native	2% (3)	2% (3)	0
Native Hawaiian or Pacific Islander	16% (27)	16% (27)	0
Other	14% (23)	12% (20)	2% (3)
Prefer not to Answer	7% (12)	7% (12)	0

Percentages may not equal 100 due to rounding.

neighborhoods. Since the beginning of the pandemic, studies have illustrated this in major cities such as New York and Washington, DC (15, 28). Similar trends in multiple states throughout the USA have been observed (29). Recent literature highlights that increased accessibility to a testing location resulted in a reduced risk for COVID-19 infection (30). In Massachusetts residential segregation of Hispanic and Black Americans was associated with a higher COVID-19 incidence rate, even though these same populations had the shortest drive time to testing sites (30). Results highlighted that SDOH such as poverty, road density, and closeness at home (more than one person to a room) were explanatory factors for these associations. As previously mentioned, one of the primary ways of wealth building in the US is through home equity meaning that those who were unable to buy homes had less opportunity to build generational wealth. This leads to less economic security in populations that were left out along racial lines. Segregated neighborhoods tend to have a higher density of people, a key driver of SARS-CoV-2 transmission. Although research has shown that living in segregated neighborhoods is associated with poor health outcomes, individual economic circumstances also play a role. Such neighborhood conditions further racial inequalities and have contributed to COVID-19 related disparities.

Economic insecurity

There is a strong bidirectional association between economics and health outcomes (31). From our preliminary findings, a significant proportion of participants had substantial decreases in their income, were concerned with job loss, and experienced food insecurity due to the pandemic. Economic instability increases vulnerability to adverse events by directly impacting the conditions required for a person's functioning in society (31). Adverse health outcomes make people more vulnerable to economic instability (31, 32). In the US, lack of employment endangers an individual and family's financial stability, and often results in the loss of health insurance—a pernicious combination—especially considering the significance of comorbid health conditions affecting COVID-19 outcomes (31, 32). Individuals with low incomes or economic instability are at increased risk for SARS-CoV-2 infection and the most severe disease outcomes (33–35). Furthermore, minoritized and racialized groups have experienced the greatest health and economic burden in part due to limited resources (33–35). In the US, the economic consequences of the pandemic have disproportionately harmed people of color, young adults, women, parents of young children, and low-income workers, exacerbating existing pre-pandemic disparities in accessing nutritious food, health care, and childcare (35). The disparate health outcomes related to type of employment are particularly disturbing (36, 37). Five times as many low-wage workers lost their jobs compared to middle-wage workers, while high-wage earners secured more jobs in the first year of the pandemic (35). Low-income earners also reported experiencing greater stress and barriers to mental health care compared to high-income earners (34). Low-wage workers who retained their jobs were at an increased risk for viral exposure, likely due to being declared part of the public facing workforce making social distancing less possible (33, 35). In the early months of the pandemic, it was reported that about 25% of adults in the USA had difficulty paying their bills—having to access savings or borrow money from friends and family to meet basic needs (33, 37). Increasing debt and continued unmet needs, especially among the economically disadvantaged, may further widen pre-existing disparities. Such disparities may have lasting multigenerational effects as the United States Census Bureau reported that the COVID-19 pandemic increased the number of Americans living in poverty, especially children (38). Child poverty has outsized effects not only on potential morbidity or mortality from COVID-19 but also on those children's health throughout their lifetime. Clearly, economic instability stemming from racism has long affected the health of minoritized individuals in the United States which has contributed to inequities in the burden of the COVID-19 pandemic for these populations.

Discrimination, racial bias, and vigilance

How individuals relate to their communities is important for understanding inequities in COVID-19 outcomes. In our study, conducted during the pandemic, the majority of participants experienced discrimination and attributed that discrimination to their race or skin color, with a portion exhibiting vigilance behaviors. For centuries, discrimination and racial bias have plagued minoritized communities and it is well known that they are associated with inequities in many outcomes such as cardiovascular disease (39, 40). The pandemic has amplified discrimination and bias for already

at-risk populations. Because of this, multiple scales were created and adapted to capture and understand the associations between racial/ethnic identity and physical and mental health outcomes associated with COVID-19. The Coronavirus Racial Bias Scale (CRBS) has revealed that American Indian/Alaskan Native, Asian, Black, and Hispanic/Latinx respondents believed the COVID-19 pandemic negatively affected societal attitudes toward people of their racial/ethnic identity compared to their White counterparts (23). The Everyday Discrimination Scale EDS has been adapted and framed for diverse populations in an effort to understand relationships between social factors and COVID-19 inequities (21, 24). For example, Liu et al. (34) used a version of the EDS that was adapted to ask if respondents had the discrimination experiences "due to people thinking they might have the coronavirus" (41). They found that Black and Asian participants were more likely to perceive COVID-19-related discrimination than other racial/ethnic groups and that perceiving discrimination was associated with increased mental distress. Discrimination disadvantages the physical and mental health of minoritized populations both in the near term, by eroding the trust that is important to providing quality health care and medical information, and in the longer term through vigilance and hypervigilance among those affected.

Vigilance and hypervigilance, defined as increased attentiveness and calculated behavior in anticipation of looming victimization, are often catalyzed by the effects of racial discrimination (20, 42). The COVID-19 pandemic has resulted in heightened vigilance for many individuals—specifically, groups disproportionately targeted due to racist beliefs and xenophobic ideologies (43). Coping styles related to vigilance and their impact on health are well documented. Individuals who perceive a strong need to remain vigilant in a given environment find themselves tense, worried, and often avoiding places and interactions where they suspect discrimination might be pervasive (24, 43). Qualitative findings posit that members of Black and Asian communities, in particular, identified a need to be more cautious and on "high alert" due to concerns of being threatened or attacked within the first few months of the pandemic (42). Further, research has shown widespread vigilance around becoming the target of racial discrimination in Black and Asian communities and association of such vigilance with increases in symptoms of anxiety and depression (43). Racial discrimination has multiple effects on the health of populations that experience discrimination both independently and through intervening variables such as health behaviors, utilization of health care, and mental and physical health.

Conclusion and policy recommendations

The COVID-19 pandemic has further highlighted the macro-level factors, such as economic, physical, and social structures, which broaden the disparities gap and play a significant role in population health. Going forward, policies that focus on racial equality and reducing disparities driven by racism are needed to improve health outcomes for minoritized populations. Over the last 2 years, hundreds of policies were put into place at a local, state, and federal level to theoretically reduce the burden of the pandemic (44). Examples of these policies include the eviction moratorium, increases in SNAP benefits, the CARES Act, the reduction of federal interest rates, the continuation of public insurance eligibility coverage, the lifting of telehealth restrictions, and increasing broadband internet access (44, 45). Armed with the disconcerting evidence of the upstream causal pathways linked to significant health disparities, policymakers now face the overwhelming task of unwinding and either terminating or adopting a form of implemented policies (44). The relentless effect of the pandemic on socioeconomically disadvantaged communities has incited an investment in health equity response efforts to avoid the expansion of long-standing disparities and triggered an interest in broad policy reform (45–47). Both within and external to the healthcare system, comprehensive actions must be taken to address the origin of these disparities, racism, and build a health equity scaffold to avoid injustices in future inevitable pandemics (44, 45, 47). Previously published research has suggested actions, including cross-sector agency collaboration by government leaders, expansion of insurance coverage, implementation of value-based payment arrangements incorporating measures of SDOH, and the incorporation of affected communities in the policy development and implementation processes, for equity-focused policy reforms (45). We hope that the momentum gained during the COVID-19 pandemic to dismantle barriers to better population health outcomes will continue.

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 portions of this study involving human participants were reviewed and approved by the UMass Chan Medical School Internal Review Board (study protocol #s H00023082 and H0023083). Participants were provided electronic informed consent to enroll in this study.

Author contributions

AM, MS, EB-N, MC-A, MG, CJ, SL, GM, AM, EM, and TW made substantial contributions to the conception and design of the work, drafted the work, provided approval for

publication for the content, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. SF made substantial contributions to the conception and design of the work, revised the work critically for important intellectual content, provided approval for publication for the content, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. AM made a substantial contribution to the acquisition and interpretation of data for the work, revised the work critically for important intellectual content, provided approval for publication for the content, and agree to be accountable for all aspects of the work in ensuring that questions related to the accuracy or integrity of any part of the work are appropriately investigated and resolved. All authors contributed to the article and approved the submitted version.

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The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Employer impact on COVID-19 vaccine uptake among nursing and social care employees in Austria

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Introduction: Since becoming available, vaccines against COVID-19 have been a focus of public debate. This is particularly relevant among healthcare and social workers, who interact with vulnerable patients and clients on a daily basis. With employers implementing educational programs and offering incentives to raise vaccine willingness among their staff, it is crucial to understand drivers of vaccine acceptance and hesitancy as well as the impact employers can play on vaccine decision-making.

Methods: We conducted a cross-sectional study *via* computer-assisted telephone and web interviews. We recruited from a pool of employees from nursing and social care institutions in Vienna and Lower Austria operated by one healthcare NGO. Variables included in the analysis were socio-demographic attributes, reasons for or against the vaccine, sources of information, opinions of mandatory vaccination, and whether respondents had previously been infected with COVID-19 or knew someone who had.

Results: 86.2% of respondents had received at least one dose of the COVID-19 vaccine. 13.8% were unvaccinated. Vaccinated respondents' main reason for getting the vaccine was to protect themselves (79.6%) as well as others (74.1%), while non-vaccinated respondents cited a fear of short or long-term side effects (58.8 and 42.4%, respectively) as their primary reason for not getting vaccinated. 72.8% of the unvaccinated said no incentive would make them change their mind, while 17.4% specified abstract concepts or systemic change as effective incentives. Monetary incentives were not seen as a motivator. Unvaccinated respondents were significantly more worried about the future than vaccinated respondents (78.8 vs. 26.3%, $p < 0.001$). They were also significantly more likely to view their employers' vaccine recommendations as "manipulative" (50.6 vs. 12.4%, $p < 0.001$), while vaccinated respondents were significantly more likely to view them as "supportive" (68.0 vs. 25.9%, $p < 0.001$).

Conclusion: While employers have the means to mediate public health decision-making by providing information, deciding to become vaccinated is a more complex process including public debate, world views, political

influences, and the uptake of information. Employers can act as mediators for public health decision-making, moving policy measures beyond an individualized view of health choices and health literacy toward more structural, systemic, and community-based efforts.

KEYWORDS

COVID-19, COVID-19 vaccine, vaccine hesitancy, vaccine incentives, employer impact

Introduction

Ever since vaccinations for COVID-19 became available in December 2020 they have been a focus of public debate. Following initial excitement about finally having an effective tool against the pandemic and a first focus on protecting healthcare workers and vulnerable populations, it quickly became apparent that many did not view the vaccine as the panacea it set out to be (1). With discourse around the safety and efficacy of vaccines becoming increasingly heated, compulsory vaccination mandates and other measures to increase vaccination rates were discussed as possible public health measures (2, 3). Meanwhile, healthcare and social care providers sought different methods of encouraging employees to get vaccinated, arbitrating between notions of freedom of personal choice on the one hand and, on the other, employees' personal protection as well as that of their patients and clients (4, 5).

Against the backdrop of this increasing tension, our study focuses on vaccination attitudes amongst employees of one large nursing and social care NGO based in Vienna and Lower Austria. As of October 2021, over 80% of the 6,000 nursing and social care employees had been voluntarily vaccinated against the virus and, with COVID-19 cases on the rise, the institution was looking for ways to increase this figure. At the time, Austria's vaccination rate lagged behind that of many other European countries: 75% of people in Austria had received at least one dose compared to 93% in Portugal, 84% in Spain, 83% in Italy, 82% in Denmark, and 80% in Norway and Ireland (6). Furthermore, the press reported that even a notable number of healthcare workers were skeptical of vaccinations and vaccination mandates (7). Austria was about to enter its third national lockdown and gained international press attention by ending the lockdown early for people who had been vaccinated or had recently recovered from COVID-19, de facto indirectly penalizing the non-vaccinated (8). Unvaccinated healthcare workers were especially harshly criticized, making the topic of getting vaccinated for the sake of patient and client safety the focus of debate (9).

Our survey, conducted in December 2021, explores the reasons and justifications given by nursing and social care employees at one Austrian healthcare NGO for receiving or refusing a COVID-19 vaccination. In computer-assisted web and telephone interviews, we asked respondents which sources they used to gather information, and what might incentivize non-vaccinated employees to change their mind and be vaccinated. The NGO in question had also been particularly active with respect to educating and informing unvaccinated employees about the vaccinations, the risks to their employees' own health, and to the health of their clients. In recent studies, the role of employers in vaccine decision-making and shaping opinions about vaccination policy measures has been repeatedly emphasized (10–12). Lazarus et al. (13) examined international differences, surveying respondents in 23 countries and asking how they would respond to an employer's hypothetical recommendation that they get vaccinated. The authors found that employers can, at least hypothetically, play an important role in mediating vaccination decision-making, and differences among countries indicate potential cultural and structural effects. This study provides a more detailed test of this hypothetical scenario in the context of Austria.

We chose to conduct our research at this specific healthcare NGO because it had been using additional measures to incentivize employees to get vaccinated as early as January 2021, the date at which the general vaccine rollout started in Austria. By the time this study was conducted, employees had consequently received a wealth of information about the benefits and possible risks of the vaccine through their workplace and had been given further opportunities to seek more information. Employees were also regularly tested for COVID-19 to avoid the spread of infection amongst high-risk clients such as older adults and persons living with physical disabilities for whom a large number of employees had care and nursing duties (14). To encourage employees to become vaccinated, managing directors decided to introduce individual, mandatory consultations with a physician about the vaccine. Non-German speakers were able to receive their consultation in their native language using tele-interpreters (15). Additionally, managing directors, employee representatives and company health officers decided to jointly send an informational letter to non-vaccinated employees. The letter addressed potential fears and concerns about the vaccine, emphasized the risk that a COVID-19 infection poses to the employee's own health and that of their patients and clients, and mandated these employees to visit the information line at one of the local vaccination centers where doctors were specifically tasked and trained to provide further information. Despite these elaborate efforts, only 5%

of non-vaccinated employees opted for a vaccination following such a consultation.

Overall, this points to deeper-seated issues structuring people's attitudes and justifications, making this a particularly pertinent issue among people whose job involves patient care. A recent study of the attitudes of midwives in Austria to measles vaccinations has shown that information and education alone do not change vaccination attitudes (16). In our study, we point to the role played by the workplace: both the potential role of broad reaching but subnational (community) efforts, and what employers can and cannot do to effectively incentivize vaccinations as a means of achieving overarching public health goals.

In our discussion, we ask how communication and policy strategies can reach unvaccinated healthcare NGO workers—and non-vaccinated people in general—in a country where a large range of relevant policy measures has already been exhausted, including the world's first vaccine mandate (17)[1].

Materials and methods

The study's main aim was to evaluate the reasons given by employees of several nursing service providers in Vienna and Lower Austria for receiving or refusing a COVID-19 vaccination. An additional aim was to identify their sources of information about the vaccine.

Design, subjects and procedure

This was a cross-sectional study conducted *via* computer-assisted telephone and web interviews. We recruited from a pool of employees at nursing and social care institutions in Vienna and Lower Austria, all operated by a single healthcare NGO.

After approving our planned survey, the employer provided us with a list of 6,033 employee work telephone numbers. Of these, 360 numbers were selected at random for calling. Six researchers conducted telephone interviews during the period December 20 to 23, 2021. During this time, we called each number at least once. $n = 36$ persons agreed to be interviewed. $n = 238$ persons answered the phone but were not willing to participate or asked to be called back and then did not answer their phone again. Where we were unable to reach a respondent (i.e., when their phone was switched off, or we only reached their mailbox), we called them again later. In 86 cases, no one answered the phone despite multiple attempts to call.

After 4 days of cold calling, our response rate was 10%. With Christmas and New Year's Eve approaching, we were not optimistic that we would reach significantly more people in the following days. We therefore decided to host the survey online and issue an email to all employees asking them to participate. Data was collected *via* the online survey from December 27, 2021, to January 10, 2022.

To prevent those who had already participated in the telephone survey from also participating online, we began the survey with the question: "In the last couple of days, have you taken part in a telephone interview about the COVID-19 vaccine?" Respondents who answered "yes" to this question were screened out. After screen out, $n = 589$ respondents completed the online survey. None needed to be excluded for quality reasons.

Measurements

We collected respondents' demographic data with respect to gender, year of birth, level of education, and country of birth. The levels of education included in the demographic data are specific to the Austrian school system and consist of "compulsory school or lower," indicating 9 years of obligatory education usually completed at age 15, "apprenticeship," which is a practical professional training, "leaving certification," the equivalent of a high school diploma, and "university / university of applied sciences," which corresponds to any kind of higher education after high school. Today, most nursing practitioners and social care workers have university-level degrees and therefore fall in the category of "university or applied sciences" (or similar diploma) category[2].

While designing the survey, we also debated including more detailed questions regarding characteristics of employees, such as exact profession (e.g., nurse/social care worker) or years of employment at the NGO. However, we opted against these data points in order to protect participant anonymity, as the political pressure for healthcare-related workers to get vaccinated was at an all-time high when we conducted the study.

The survey's main section began by asking whether respondents had been vaccinated against COVID-19, and if yes, how many times. Depending on this answer, we then asked respondents their reasons for or against vaccination. All respondents were asked if and where they had sought information on the vaccine. We asked unvaccinated respondents about any potential incentives which would encourage them to get vaccinated, and whether they would get vaccinated if this became mandatory as the Austrian government had announced that the COVID-19 vaccination would become compulsory from February 2022. All respondents were asked if they were in favor of vaccination being made mandatory. On a five-point Likert scale, we asked respondents how worried they were about the

1 However, after it was discovered that the Omicron variant proved less of a threat than Delta, the vaccine mandate was never enforced and was quietly discarded in June 2022 (18).

2 https://www.sozialministerium.at/Themen/Gesundheit/Medizin-und-Gesundheitsberufe.html

upcoming vaccination mandate, and then asked if they would like to speak to someone about their fears and anxieties, and, if yes, with whom (e.g., an anonymous telephone hotline or a counselor).

The last section of the survey asked respondents whether they or someone they knew had contracted COVID-19, and, if yes, how severe the progression of the disease had been. Respondents were also asked what they thought of their employer's efforts to encourage vaccination.

Finally, we asked respondents whether they wanted to add further thoughts and/or comments.

Questions asking for reasons for or against getting vaccinated, sources of information, potential incentives, and the persons with whom respondents would like to speak allowed for multiple-choice answers, and also included an open-ended text field for respondents to provide additional answers. The pre-specified reasons were selected based on common answers given to healthcare workers in our research team in their daily practice, and a pre-test of the questionnaire with team members, so as to include the most commonly anticipated answers.

We included "because it is fearmongering" and "COVID-19 is not a serious disease" as two possible reasons against the vaccine. Although they seem somewhat overlapping, we nevertheless distinguished between these two items as we felt that not viewing COVID-19 as a serious disease reflects a more personal motivation, while rejecting the vaccine because it is "fearmongering" can also express a political motivation, to demonstrate resistance against the information on COVID-19 and the way it had been dispersed. The pre-test of the survey confirmed this distinction, so we opted to include both reasons despite the slight overlap.

To account for reasons not anticipated by team members and in the pre-test, we also included the option of open-ended answers.

We chose not to include a previous infection with COVID-19 as a reason against the vaccination as per the Austrian vaccination commission, a previous infection only serves as immunization for 6 months. As the vaccination had already been available for 1 year by the time we conducted this study, even previously infected respondents may have spent at least 6 months without a valid immunization status. Based on these considerations, we decided to exclude a previous infection as a reason against getting the vaccine. Respondents were however able to cite a previous infection as a reason against getting the vaccine in the open text field.

Data analysis

Data analysis was conducted using IBM® SPSS® Statistics, version 26.0.0. We conducted descriptive analyses, first calculating frequencies and percentages, and, where applicable, mean, median and standard deviation. Numeric variable age was assigned into categories for inclusion in cross tabulations; for scaled questions, we also calculated top 2/bottom 2 values. We used Pearson's Chi-squared test or Fisher's exact test to determine group differences between categorical variables, and Student's t-test for continuous variables. A two-sided probability value of <0.05 was considered significant. We used vaccination status as a dependent variable and compared it to all demographic variables (age, gender, level of education, and country of birth). Open-ended text field responses were categorized and included in the statistical analysis as additional variables.

Respondents' final thoughts and comments were analyzed qualitatively. Three independent reviewers identified common themes through iterative engagement with the responses. Findings were compared. In the case of discrepancies, discussions with two additional researchers were held to reach consensus.

Results

In total, 625 respondents completed the survey, 36 (5.8%) *via* telephone and 589 (94.2%) *via* online survey. 73.2% ($n = 444$) of the sample identified as female, 26.4% ($n = 160$) as male and 0.5% ($n = 3$) as diverse. The age of respondents ranged from 19 to 65 years (M = 42.7, SD = 10.56). Further socio-demographic characteristics can be found in Table 1.

Of the 617 respondents who disclosed their vaccination status, 86.2% ($n = 532$) had received at least one dose of the COVID-19 vaccine; 13.8% ($n = 85$) were unvaccinated.

Reasons for or against the vaccine

The primary reason for getting vaccinated given by vaccinated respondents was to protect themselves (79.6%) as well as others (74.1%), followed by the vaccine's societal importance (61.9%) and the ability to participate in social life again (47.8%). Less often cited reasons were a recommendation by employers (19.1%), physicians (7.3%), or friends and family members (6.9%), while 3.8% admitted they had "just done it" without giving it much thought. 10.9% gave an additional reason in the open-ended text field, most frequently citing pressure from their employer (3.9%).

The primary reason given by unvaccinated respondents for not getting vaccinated was fear of short or long-term side effects: 58.8% expressed uncertainty about potentially negative long-term effects; 42.4% cited negative short-term side effects (headache, fatigue, or fever) suffered by friends, family members or their patients and clients; 18.8% said they were willing to get vaccinated but were currently waiting for a different vaccine to be approved, one which they deemed safer. Other reasons given for not getting vaccinated related to the severity of COVID-19:

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TABLE 1 Frequencies and percentages for demographic data.

Demographic characteristics	Total ($n = 625$) n (%)	Vaccinated respondents ($n = 532$) n (%)	Unvaccinated respondents ($n = 85$) n (%)
Gender			
Male	160 (26.36)	140 (26.77)	20 (24.39)
Female	444 (73.15)	382 (73.04)	60 (73.17)
Diverse	3 (0.49)	1 (0.19)	2 (2.44)
Vaccine status			
Vaccinated once	18 (2.92)	18 (3.38)	0 (0.00)
Vaccinated twice	88 (14.26)	88 (16.54)	0 (0.00)
Vaccinated three or more times	426 (69.04)	426 (79.70)	0 (0.00)
Not vaccinated	85 (13.78)	0 (0.00)	85 (100.00)
Country of birth			
Austria	(76.02)	410 (77.80)	234 (64.63)
Not Austria	(23.98)	117 (22.20)	36 (35.37)
Level of education			
Compulsory school or lower	25 (4.30)	19 (3.82)	3 (3.85)
Apprenticeship	22 (16.67)	77 (15.49)	19 (24.36)
Leavin certification	97 (22.16)	107 (21.53)	19 (24.36)
University/ University of applied sciences	129 (56.87)	291 (58.55)	37 (47.44)

TABLE 2 Reasons for or against getting the COVID-19 vaccine.

Reason	n	%
For getting the vaccine		
Protecting oneself	424	79.55
Protecting others	395	74.11
Societal importance	330	61.91
To participate in social life again	255	47.84
Recommended by employer	102	19.14
Recommended by physician	39	7.32
Recommended by friends/family	37	6.94
Just did it	20	3.75
Other	58	10.88
Against getting the vaccine		
Fear of long-term effects	50	58.82
Because it is fearmongering	36	42.35
Fear of short-term effects	36	42.35
No trust in experts	30	35.29
Alternative protection	25	29.41
Because the government uses it to control its citizens	24	28.24
COVID-19 is not a serious disease	19	22.35
Waiting for another vaccine	16	18.82
Pre-existing condition	8	9.41
Want to have a baby	7	8.24
Friends/family advised against	5	5.88
General rejection of vaccines	5	5.88
Lack of information	4	4.71
Physician advised against	4	4.71
Afraid of needles	1	1.18
Pregnancy	1	1.18
Other	37	43.53

Data is presented as frequency and percentage of a total n of 533 (for the vaccine) and 85 (against the vaccine).

42.4% thought the media and politicians were fearmongering, and 35.3% said they did not trust experts who spoke out in favor of the vaccine; 29.4% stated they took a variety of protective measures (wearing a mask, washing hands, regular exercise, taking vitamins, etc.); 28.2% said they thought the government was trying to control its citizens and consequently did not want to follow the vaccine recommendations; and 22.4% expressed the belief that COVID-19 was not a serious disease.

Medical reasons for not getting vaccinated were cited less frequently: a pre-existing condition (9.4%); the wish for a child (8.2%); general vaccine skepticism (5.9%); fear of needles (1.2%); or a current pregnancy (1.2%). Recommendations against vaccination issued by friends or family (5.9%) or physicians (4.7%) were also cited. 4.7% said they had not (yet) been vaccinated because they lacked information on the subject.

43.5% offered additional reasons for not getting vaccinated, most commonly reiterating their skepticism toward the vaccine's safety and efficacy, with three respondents referring to persons who had died or suffered irrevocable damage to their health following vaccination, cases of which they knew from hearsay. Six respondents cited their general disapproval of the way the government had handled the pandemic (e.g., contradictory regulations, the distribution of COVID-19 aid packages for companies in danger of bankruptcy, or politicians' general lack of trustworthiness) as a reason against vaccination (Table 2).

Sources of information

Analysis of the differences between vaccinated and unvaccinated respondents with respect to sources of information revealed significant differences for five sources: respondents who were vaccinated were more likely to read a daily newspaper (41.4 vs. 25.9%, $p = 0.007$) while respondents who were unvaccinated more often consulted the internet (37.7 vs. 25.9%, $p = 0.025$), their primary physician (27.1 vs. 16.4%, $p = 0.017$), other physicians (48.2 vs. 23.1%, $p < 0.001$), or other sources such as TV news or programs (27.1 vs. 10.3%, $p < 0.001$).

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TABLE 3 Sources of information.

Item	Vaccinated respondents ($n = 532$) n (%)	Unvaccinated respondents ($n = 85$) n (%)	*p-value*
Academic articles	305 (57.33)	45 (52.94)	0.448
Employer	216 (40.60)	33 (38.82)	0.756
Daily newspaper	220 (41.35)	22 (25.88)	0.007
Internet	138 (25.94)	32 (37.65)	0.025
Non-primary physician	123 (23.12)	41 (48.24)	<0.001
Friends/acquaintances	123 (23.12)	28 (32.94)	0.051
Family	93 (17.48)	20 (23.53)	0.181
Primary physician	87 (16.35)	23 (27.06)	0.017
Colleagues	67 (12.59)	24 (28.24)	<0.001
Somewhere else	55 (10.34)	23 (27.06)	<0.001
Did not seek out information	14 (2.63)	2 (2.35)	0.881
Telephone hotline	7 (1.32)	2 (2.35)	0.459

TABLE 4 Possible vaccination incentives and response to vaccine mandate.

Item	Unvaccinated respondents ($n = 85$) n (%)
Incentive	
No incentive could change mind	67 (72.83)
Abstract concepts/systemic change	16 (17.39)
Monetary incentive (EUR 50)	0 (0.00)
Monetary incentive (EUR 50)	1 (1.09)
Response to vaccine mandate	
Would rather lose my job than get vaccinated	55 (74.32)
Would only get vaccinated if the alternative was losing my job	14 (18.92)
Would get vaccinated if it was mandatory	5 (6.76)

Differences between the groups with respect to sources of information is shown in Table 3.

Mandatory vaccinations

Unvaccinated respondents were asked which incentives could make them change their mind about getting the vaccination. 72.8% said no incentive could make them change their mind, while 17.4% specified abstract concepts or systemic change, such as "if politicians lied less" or "if vaccinations were safer." Monetary incentives were not seen as a motivator: no respondents were willing to get vaccinated for EUR 50, and only one was willing to do it for EUR 500. When asked if they would get vaccinated once it became mandatory, most respondents (74.3%) stated they would rather lose their job than get vaccinated, while 18.9% said they would only get vaccinated if this was required to keep their job (Table 4). Correspondingly, only one unvaccinated respondent (1.2%) was in favor of mandatory vaccinations compared to 64.6% of vaccinated respondents. Unvaccinated respondents were significantly more worried about the general future than vaccinated respondents (78.8 vs. 26.3%, $p < 0.001$). They were also significantly more likely to view their employers' vaccine recommendations as "manipulative" (50.6 vs. 12.4%, $p < 0.001$), while vaccinated respondents were significantly more likely to view these efforts as "supportive" (68.0 vs. 25.9%, $p < 0.001$) (Table 5).

TABLE 5 Feelings related to vaccine mandate and employer information.

Item	Vaccinated respondents ($n = 528$) n (%)	Unvaccinated respondents ($n = 84$) n (%)	*p-value*
Opinions on vaccine mandate			
In favor of vaccine mandate	296 (64.63)	1 (1.23)	
Worried about the general future	140 (26.32)	67 (78.82)	<0.001
Perception of employer information			
Manipulative	66 (12.41)	43 (50.59)	<0.001
Supportive	362 (68.05)	22 (25.88)	<0.001

COVID-19 infections

Respondents who were unvaccinated at the time the data was collected had already been infected with COVID-19 more often than vaccinated respondents (28.6 vs. 12.7%, $p < 0.001$), although they were only slightly more likely to have been hospitalized (one case in each group).

No significant differences could be gleaned from the comparative analysis of respondents who were vaccinated and those who were unvaccinated with respect to whether they knew someone who had been infected with COVID-19, and if so, how severe the course of the disease had been for that person (Table 6).

Discussion

This extensive study involving over 600 participants—all employees of a healthcare NGO in Austria—surveyed

TABLE 6 COVID-19 infection.

Item	Vaccinated respondents ($n = 528$) *n* (%)	Unvaccinated respondents ($n = 84$) *n* (%)	*p-value*
Self			
Had COVID-19, home quarantine	6 (12.50)	23 (27.38)	
Had COVID-19, hospitalized	1 (0.19)	1 (1.19)	
Had COVID-19, ICU	0 (0.00)	0 (0.00)	
Did not have COVID-19	461 (87.31)	60 (71.43)	<0.001
Someone they know			
Had COVID-19, home quarantine	157 (29.85)	21 (25.00)	0.364
Had COVID-19, hospitalized	99 (18.82)	19 (22.62)	0.415
Had COVID-19, ICU	135 (25.67)	17 (20.24)	0.285
Know no one who had COVID-19	135 (25.67)	27 (32.14)	0.214

employee motivation behind the acceptance or refusal of a COVID-19 vaccine, the information they had gathered in order to make this decision, and in particular the role of employer incentives and measures in their decision-making process. Furthermore, the study assessed the impact of country-wide policy discussions such as potential vaccine mandates on individual vaccination decisions. Below, we discuss the implications of our findings for COVID-19 vaccination motivation in general, and with a focus on the role of employers as mediators in employee decision-making processes when it comes to public health goals such as vaccination.

Regarding the decision to become vaccinated, our study found no major differences between our study population of a healthcare NGO's employees compared to the rest of the Austrian population (19). The overriding factor behind the decision to get vaccinated was personal protection and to protect others, and to similar degrees. The study had hypothesized that protecting others might score higher amongst nursing and social care employees than in the rest of the population as many of the study participants were either healthcare workers themselves and had direct patient contact, or, as a result of working within the organization, had seen firsthand how COVID-19 had endangered some vulnerable people in the NGO's care. However, this assumption was not confirmed by the data. This suggests the study might add to the growing body of literature indicating that patient care and care work more generally are problematic predictors for vaccine decision-making (20–22). It should be noted that not all study participants had direct contact with vulnerable patients, and, for reasons of anonymity, additional data was not acquired to establish such differences. Therefore, any correlation between getting vaccinated against COVID-19 to protect others and working in direct contact with patients cannot be statistically confirmed. In open answers given by participants, however, references to work with clients/patients was repeatedly specified as a (co-)motivation for vaccination. In some cases, this was even given as the primary motivation where the study participants did not feel they themselves needed protection from an infection in the form of a vaccine. More in-depth research, especially on the quality of such motivation, is needed.

19.1% of participants said that their employer's recommendation had at least played a partial role in getting vaccinated. In the open answers, an additional 3.9% said they had felt pressured by their employer to get vaccinated, highlighting how employers can and do have a measurable impact on public health. This reflects recent findings, such as a large-scale survey by Fishman et al. which showed that employer mandates had a significant effect on vaccination decision-making (23). Other authors have also examined the impact of other non-"crime and punishment" measures, such as incentives and the reduction of what Njoku et al. (24) call "structural barriers," including paid leave (25), easy access to non-traditional vaccination locations (26), or administrative facilitations by employers (27), and identified their incentivizing potential. Our study concurs with these results, confirming that employers can play an important role as mediators in vaccine decision-making and can, indeed, be regarded as a resource in public health policies for future vaccine rollouts. However, more detailed research on the quality of such actions is necessary, especially in terms of "softer" incentives and mediating motivators, such as (mis)trust in the employer (11, 12).

This is particularly pertinent considering that, at the time the study was conducted, there were heated political and public debates on whether to instate a vaccine mandate for COVID-19 for the general population, or at least for people in the healthcare sector, with both policies directly affecting most of our study participants. Our study found that this would have little effect on peoples' reported behavior, in some cases even making the participants more determined not to get vaccinated as a means of expressing their own free will. While the study merely asked what people would do if a vaccine mandate were to be instituted (rather than verifying that these claims were being put into practice), this outcome is still valuable for assessing the possible effects of a vaccine mandate, whether a universal mandate or only for those working in the healthcare sector. In open questions, the participants' reasons for refusing to get vaccinated, even with a mandate in force,

became apparent: many voiced grave concerns regarding their own health, even stating that they believed their life to be in acute or long-term danger if they were to receive the vaccine. Consequently, while not a desirable outcome, losing their job or having to pay a fine for defying a vaccine mandate seemed a comparatively small price to pay to protect one's health or even life. As one participant said, "What good will a job do me if I'm dead?".

Furthermore, some respondents saw not getting vaccinated as an act of civil disobedience, giving them a means of expressing their resistance to a political system that, according to them, encroached on their physical and health autonomy. While pressure acted as a motivator behind some respondents' decision to get vaccinated, high-stakes "crime and punishment" measures may have a significant, detrimental effect on precisely those at whom they are targeted. "Softer" measures, such as providing opportunities to receive more information or easy access to on-site vaccination would seem preferable. In many cases external factors such as distrust in and resistance to (governmental) power will trump any measures taken by the employer.

Similarly, the main reason given by study participants (as in the population as a whole) for refusing a COVID-19 vaccination is mistrust in the vaccine itself, combined with disbelief in the information provided by medical professionals, the government, or both. The fact that many of our participants have medical training or above-average knowledge of medical issues as a result of their profession did not alter this outcome. Instead, people used their expert knowledge to justify their personal choice not to be vaccinated, using arguments and methods that can be ascribed, at a general level, to scientific practice: such as in-depth research, consulting medical journals, citation, evaluating the quality of sources according to factors perceived to determine "scientificity," or postponing their decision based on risk assessments, weighing the risk of a COVID-19 infection against the health risk they associate with the COVID-19 vaccine [see also (28)]. The study found fewer differences than expected between vaccinated and unvaccinated respondents in terms of the sources of information participants reported to have accessed to inform themselves about the COVID-19 vaccination. Both those who opted for the vaccine and those who did not reported having referred to daily media outlets, the internet and (primary) physicians when making their decision. In the open answers, several participants who opted against the vaccine stressed that they had used "scientifically solid sources of information," such as physicians' advice and scientific journal articles to make their choice. Other studies about attitudes toward vaccines amongst medical professionals in Austria have recently produced similar findings, noting that information alone does little to persuade people who are hesitant to vaccinate, especially healthcare experts, if more structural factors are not taken into account (16). Moreover, people may decide based on their existing world or political views, or on a primarily emotional basis, that they will or will not get vaccinated, and then both seek out and interpret medical information accordingly to substantiate their decision. Consequently, increased health literacy certainly can lead to increased patient empowerment (29), as individuals feel they have all necessary information available to make health decisions best suited to their needs, and, in fact, might objectively increase the level of understanding regarding the consequences of health decisions (30). However, while low health literacy is associated with poorer health outcomes (31), the opposite is not necessarily true, as our study, and others, have found. Thus health literacy does not necessarily guarantee a different behavioral outcome (32).

Despite widespread similarities in the sources of information, the differences shown in the data are indeed meaningful. Respondents who were not vaccinated reported using internet sources more frequently, in addition to or instead of daily media outlets such as newspapers and TV. This could indicate that this group decided to gather their own information rather than merely consuming mainstream media sources. This accords with the questioning of public authorities such as politicians and researchers, leading them to seek out other sources of information. This does not necessarily mean that unvaccinated study participants consumed questionable, lower-quality sources of information than their vaccinated counterparts. Instead, it could also indicate that they consumed similar sources, such as scientific journal articles, as noted above, but drew different conclusions from what they read. In an open answer, for example, one participant gave the correct efficacy rate for the COVID-19 vaccine in question but concluded that this did not provide sufficient protection from infection to outweigh the possible risks of vaccination. Overall, most study participants—both vaccinated and unvaccinated—appeared to be well informed and to have made a conscious decision.

Another finding in this context is the role of physicians and other health professionals in shaping opinions. Both vaccinated and unvaccinated study participants claimed to have followed their physician's advice (not) to receive a COVID-19 vaccine, with general practitioners having been named more frequently in this context by non-vaccinated individuals. This showcases the crucial role of health professionals as opinion leaders and mediators in the decision-making process. From the perspective of an employer wanting to motivate employees to partake in public health measures such as vaccinations, this indicates that building trust between occupational health physicians and employees could significantly impact the success of health measures.

Conclusion

It should be reiterated that many of our respondents work as caregivers and thus have an above-average level of medical expertise. As a result of their employer's extensive dissemination of information on the COVID-19 vaccine, they had also had manifold opportunities to educate themselves on the benefits of the vaccine. This, together with the fact that respondents work with and care for vulnerable and at-risk groups, led to a feeling of shame in many of those respondents who had decided not to receive the vaccination (yet). The phone interviews in particular made this palpable: many as-yet unvaccinated respondents expressed relief that this study finally gave them the chance to voice reasons for their hesitancy in a judgment-free environment. This phenomenon has been dubbed "unspoken vaccine hesitancy" by Heyerdahl et al. (33), who state that "especially among healthcare workers, merely voicing vaccine-related concerns entails a risk of being lectured, mocked, stigmatized, or labeled as conspiracy theorists and 'anti-vaxxers'" (p. 1). In this sense, this study also provided a space for people to voice such opinions, highlighting that vaccine hesitancy or vaccine refusal are complex phenomena and take place on a spectrum more complicated than a mere yes/no choice (34, 35). In the same sense, people who choose not to vaccinate are not "beyond help," and incentivizing measures can indeed make a difference—but there is no "one size fits all"-solution.

Providing holiday coupons, financial incentives, or entering unvaccinated people into a lottery to win attractive prizes—measures which were discussed or implemented in Austria (36)—are not panaceas, nor often a sufficiently weighty counterbalance for those truly concerned about endangering their wellbeing with a vaccine. Employers have the means to mediate public health decision-making by providing employees with information, but vaccination decision-making is a more complex process that involves public debates, world views, political influences, and the uptake of the information provided. As a result of the NGO's efforts to educate and incentivize, the vaccination rate among our respondents was 86.2% and thus already higher than that of the Austrian general population which was around 75% at the time (6). Nevertheless, a crucial minority of NGO employees had decided against getting vaccinated. The NGO's efforts were an important contributor to vaccination decision-making, but not sufficient to achieve a full vaccination rate among its staff. We conclude that employers need to be taken seriously as mediators for public health decision-making, moving policy measures beyond an individualized view of health choices and health literacy toward more structural, systemic, and community-based efforts (37). Employer incentives should be thought of as a "connected effort," one that intersects with a network of reasons for vaccine decision-making. This present study has pointed to informational incentives, measures tailored to the workforce (e.g., healthcare institutions need to take the professional client relationship into account), the potential role of occupational medicine as "in-house" opinion leaders—assuming trusting relationships can be established—and the importance of a varied approach which goes beyond "crime and punishment" mandates.

Overall, there cannot be a one-size-fits-all approach to complex health decision-making, especially in times of crisis. If a common goal is to be achieved, measures to achieve this goal need at least to try to bring everyone into the fold.

Limitations

This study is not without limitations. Firstly, cross-sectional studies have some general disadvantages: they depict only one moment in time, and it is difficult to make causal inferences (38). Secondly, we must note the unique profile of our study participants: as our participants work for a nursing and social care NGO, we argue that the profession in which they work already shapes their perception of matters related to public health, such as a global pandemic. We therefore cannot use our data to draw conclusions for the Austrian population as a whole. Even among nursing and social care employees, our respondents represent a minority: before the beginning of our study, their employers had already disseminated information about the vaccine, recommended the vaccine, and even implemented individual mandatory consultations with a physician for all unvaccinated employees. Other nursing service providers whose respondents were not included in our study had not taken similar measures to inform and encourage their employees to get vaccinated.

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 Review Board for the Viennese Hospitals in the Vinzenz Holding. The patients/participants provided their written informed consent to participate in this study.

Author contributions

TW-T, MK-P, SV-K, and EK conceived of the study. SK, ME, AT, MG, and A-KR conducted the telephone interviews. A-KR programmed the survey online and performed the statistical analysis. ME and A-KR drafted the final manuscript and performed all necessary revisions. All authors participated in the design of the study. All have authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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"I'm luckier than everybody else!": Optimistic bias, COVID-19 conspiracy beliefs, vaccination status, and the link with the time spent online, anticipated regret, and the perceived threat

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The catastrophic wave in the fall of 2021 drove Romania to the top of the list of dangerous COVID-19 infections, with the highest mortality rate in Europe. At the same time, Romania had one of the lowest vaccination rates. In this context, the present research aimed to explore the link between vaccination intention/status, optimistic bias, COVID-19 conspiracy beliefs, the time spent online, and vaccination (anticipated) regret. Our convenience sample was formed by 408 adults aged 18–63 years (M = 22.11, SD = 6.18, 69.9 % females), who were distributed into four groups: (1) non-vaccinated who definitely refused COVID-19 vaccination, (2) non-vaccinated who considered COVID-19 vaccination, (3) non-vaccinated who reported their absolute willingness to COVID-19 vaccination, and (4) people who were COVID-19 vaccinated. We conducted our analyses separately, depending on these groups (i.e., vaccination intentions/status). Data were collected using an online questionnaire between November 10, 2021, and January 03, 2022. In our cross-sectional approach, following correlation and ANOVA analyses, among the observed patterns were (1) the significant negative relation between optimism bias and the perceived COVID-19 threat; (2) the positive link between anticipated regret, post-vaccination regret, age, and conspiracy beliefs. We discuss our findings considering their contribution to health policies and practices.

KEYWORDS

COVID-19, conspiracy beliefs, vaccination, threat, anticipated regret

Introduction

Toward the end of 2019, the WHO (1) Headquarters was informed about cases of pneumonia of unknown etiology identified in the city of Wuhan, Hubei Province in China. Furthermore, the World Health Organization declared an international pandemic on March 11, 2020, after the new SARS-CoV-2 virus quickly spread to almost all countries around the globe (2). COVID-19 is a respiratory infection whose severity ranges from asymptomatic to severe and fatal disease. At the time of writing (August 2022), there have been more than 3 million confirmed cases of COVID-19 and over 66.000 deaths in Romania. Concerning the COVID-19 vaccination, more than 16 million vaccine doses have been administered (1).

However, at the time this research was conducted—at the end of 2021—Romania was ranked penultimate place in Europe, before Bulgaria, regarding the vaccination rate against COVID-19 (3). This was intriguing since, during the same time, Romania reported the highest mortality rate in Europe, with more than 500 deaths per day (4). Thus, it is essential for public health communication, strategies, and practices in the global fight against COVID-19 that we understand the motivational roots of vaccine hesitancy, one of the most controversial issues discussed in the past year.

Beliefs in COVID-19 conspiracy theories (CTs), lower educational levels, inadequate knowledge of COVID-19, younger age, and female gender are among the most common factors that indicate a refusal to vaccinate [see (5, 6) for reviews]. Factors that predict COVID-19 vaccination acceptance include the (high) perceived risk of COVID-19, an older age, trust in scientific experts, and accurate general information related to the COVID-19 vaccine (7, 8). In addition to these documented factors, the present research also aimed to explore the role of some less explored factors, i.e., optimistic bias, the time spent online, and anticipated regret when discussing COVID-19 vaccination intentions and status.

Risk perception and response

Given the magnitude of the health crisis caused by COVID-19, the factors underlying preventive behaviors and compliance with protective measures become highly important. According to the Health Belief Model [HBM (9)]. and the Theory of Planned Behavior [TPB (10)], individuals adopt behaviors to minimize the threat of a disease when they perceive themselves to be more susceptible to developing that disease, and counteracting the disease would have severe consequences (11). In the case of the COVID-19 pandemic, individuals are more likely to engage in preventive behaviors if the severity and perceived susceptibility are high (11–15).

From the Health Beliefs Model perspective, the perceived threat is a significant driver of people's preventive actions. Specifically, the perception of a threat is positively related to individuals' intention to take protective actions (16). Furthermore, the perceived threat was recently linked to TBP components, and results showed that the perceived threat could predict behavioral intentions related to COVID-19 when mediated by attitudes and social norms (17). Regarding people's intentions (prospective behaviors), according to the Theory of Planned Behavior (10), behavior is predicted by intention, and intention is influenced by attitudes toward the behavior, subjective norms, and perceived personal control.

In the context of the COVID-19 pandemic, it has been observed that the higher the perceived threat, the more individuals seem to adhere to government measures and favor compliance with instructions aimed at avoiding contamination and the spread of the virus (13, 18, 19). Moreover, regarding vaccination, several studies suggested that high levels of perceived threat might have a direct effect on vaccination intention but also an indirect effect by influencing the decrease in beliefs related to conspiracy theories [e.g., (20, 21)].

Optimistic bias

An individual's evaluation of risk vulnerability, risk severity, treatability of a malady, and the viability of preventive actions represents a series of components from the field of health psychology related to health-promoting behavior that belongs to risk perception (22). Sometimes human beings have a remarkable tendency to see the "fuller side of the glass" in everyday life, distorting their own risk in situations that could put them in danger. This phenomenon is known as *optimism bias* or *unrealistic optimism,* and according to Weinstein (23), it usually appears when an individual perceives their own risk to be lower than others. More precisely, in the case of this bias, the person's perception that their own risk of experiencing negative situations is lower than others leads to experiencing more positive conditions than others (24).

In previous studies, optimism bias has been associated with several risk behaviors, such as smoking, excessive alcohol consumption (25), and coronary heart disease (26). Regarding the COVID-19 pandemic, optimism bias has been associated with a lower perceived risk of infection (11, 27) and poorer adherence to prevention behaviors like wearing masks and social distancing (24, 28, 29). Regarding vaccination, it has been suggested that optimism bias may negatively influence vaccination intentions because people subject to optimism bias do not believe they need the vaccine as long as their risk of infection is low (30). However, previous studies have not found, until the present, a significant association between optimism bias and COVID-19 infection rates (31, 32).

Conspiracy beliefs and COVID-19 vaccination

The COVID-19 conspiracy beliefs and theories generally promote the idea that the virus is not contagious and results from laboratory manipulations created to profit by distributing new vaccines (33). People's beliefs in conspiracy theories related to COVID-19 are an essential factor often negatively associated with the engagement in preventive behaviors and positively with pseudoscientific practices (33–35). For example, in a study by Maftei and Holman (20), personal compliance with lockdown rules was higher among participants who did not have convictions of possible conspiracies.

Moreover, previous research indicated that conspiratorial ideas discourage vaccination and influence negative attitudes toward vaccination (36–42). According to Maftei and Holman (43), among people who usually strongly believe in conspiracy ideas (e.g., the virus does not exist; governments invented the pandemic; the flu or even a product of Big Pharma), beliefs in conspiracy theories partially mediated the relationship between perceived threat and willingness of participants to vaccinate.

Does the time spent online matter?

During this COVID-19 global health crisis, large-scale misinformation has significantly impacted the population's reluctance to vaccinate through relatively unregulated and decentralized platforms (44). Frequent exposure to negative information about COVID-19 vaccines on social media was associated with a lower vaccination rate (42, 45). For example, Ghaddar et al. (39) observed that a third of the sample, which showed a low vaccination rate, were dependent on social networks such as WhatsApp, Facebook, or Instagram and used them as primary sources of information. A significant positive relationship was also observed between vaccination hesitancy and frequent use of social networks such as Snapchat and TikTok; however, the strongest association was with excessive use of YouTube (44).

At the same time, other studies suggested a significant positive relationship between frequent exposure to social media content, interpersonal discussions, and vaccination intentions (46, 47). In addition, the excessive use of content on social networks was positively associated with a positive change in prevention behaviors and with obtaining the emotional, social, and informational support people need in this delicate period (46, 48). Thus, the findings in this area are mixed and call for further research.

Vaccination anticipated and subsequent regret

According to the Regret Theory (49, 50), people anticipate the feelings they might experience when the outcome of a decision becomes obvious (50). Thus, analyzing the possible negative consequences of a decision that must be taken could trigger the appearance of anticipated regret (32). Anticipated regret is composed of anticipated regret for action and anticipated regret for inaction (49). The difference between the two in the context of the COVID-19 vaccination is that anticipated regret for vaccination negatively predicts the intention to vaccinate compared to anticipated regret of not vaccinating, which is a positive predictor of it (51, 52).

Concerning the COVID-19 pandemic, anticipated regret seems to be a significant predictor of hesitancy toward the COVID-19 vaccine (32, 53). This relationship is also supported by previous research on vaccination; for example, in the case of HPV vaccination, it was observed that anticipated regret for not vaccinating was a significant predictor of vaccination intention, and its ratings are higher than those of regret for vaccination (54, 55).

Regret aversion guides individuals' actions even after the decision is made and the action taken because the regret caused by actual negative feedback on foregone outcomes can influence subsequent decision-making (56). Thus, the negative result of a decision that triggers the experience of post-decisional regret can change how a person behaves when faced with another similar decision (57). In several studies, subsequent regret has been associated with psychological stress, depression, and anxiety, concerning health risk decisions (58, 59).

In the context of the COVID-19 pandemic, Luo et al. (47) observed that respondents with higher post-decisional regret scores were less willing to receive the booster dose. The results of this study indicate that regret over previous decisions could significantly mediate the impact of post-vaccination adverse reactions on willingness to take the booster dose.

The present study

Previous research suggests that several psychological elements identified by the Theory of Planned Behavior [TPB (10)] influence health-related behaviors [including COVID-19 vaccination (43)]. TPB states that attitude, subjective norms, and perceived behavioral control shape people's behavioral intentions. Adiyoso and Wilopo (17) suggested that threat perception might predict behavioral intentions related to COVID-19 when mediated by attitudes and social norms, in line with earlier findings on risk perception in health-related circumstances (60). At the same time, high levels of perceived threat might directly impact vaccination acceptance and

intentions, but they also indirectly influence the decrease in beliefs related to conspiracy theories [e.g., (21, 43). Also, optimism bias may negatively influence vaccination intentions (30) due to a low COVID-19 threat perception (11). Next, previous studies suggested that anticipated vaccination regret negatively predicted vaccine reluctance (32, 53), and non-vaccination regret positively predicted COVID-19 vaccine acceptance (51, 52). Also, exposure to negative information about frequent social network use was associated with a lower vaccination rate (39, 44), though the findings in this area are mixed (46, 47).

Thus, the main assumptions of the present study were the following: *H1*. There would be significant negative associations between optimism bias and the perceived threat, regardless of participants' vaccination status and intentions; *H2*. There would be a significant positive association between optimism bias and anticipated regret for vaccination in the case of participants who have not yet been vaccinated; *H3*. There would be a significant negative association between optimism bias and anticipated regret for not vaccinating in the case of participants who have not yet been vaccinated and *H4*. There would be a significant positive association between optimism bias, conspiracy beliefs, the perceived threat, and the time spent online, regardless of vaccination status.

Methods

Participants and procedure

Four hundred and eight adults formed our final convenience sample from Romania aged 18–63 years ($M = 22.11$, $SD = 6.18$). Of the total respondents to the study, 69.9% were female, 29.4% were male, and 0.7% reported other genders. According to Lin et al. (61), the age groups our participants fall into are the *youth* group (18–47) and the *middle-aged* group (48–63) (please see Table 1a). Of the 408 participants, 2.2% ($N = 9$) had a secondary school diploma, 77% ($N = 314$) a high-school diploma, and 20.8% ($N = 85$) had a university degree. Twenty-three participants from the initial sample were excluded due to age criteria (i.e., all participants had to be over 18), whereas another was removed because they disagreed with data processing. There were no other inclusion/exclusion criteria.

The present study's data were collected online through an online questionnaire and distributed *via* social media platforms and communication groups (Facebook, Instagram, Messenger, and WhatsApp). We targeted Romanian-only groups (i.e., the items were all written in Romanian). The research link was accompanied by information regarding the purpose of the research (i.e., the exploration of the factors related to the COVID-19 general response). The data collection period was between November 10, 2021, and January 03, 2022.

All participants voluntarily took part in this study, and they were informed that the information they provided would remain anonymous and confidential and that they could retire from this study at any time. The time needed to complete the questionnaire was around 15 min. The research was conducted following the Helsinki Declaration ethical criteria and the ethical research requirements approved by the institutional board of the authors' institution.

Measures

COVID-19 vaccination intentions/status (outcome variable)

Participants' intentions to vaccinate were measured using an item targeting vaccination status, and the answer options were coded from 1 to 4, where 1 means *I have not been vaccinated against COVID-19 and I categorically exclude this possibility*, 2 means *I have not been vaccinated against COVID-19, but it is possible to do so*, 3 means *I haven't been vaccinated yet, but I'm sure I will*, and 4 means *I've already been vaccinated*.

TABLE 1a Descriptive statistics for the main variables (overall sample, $N = 408$).

Variable	M	SD	Min	Max	Skewness	Kurtosis
Age (overall, $N = 408$)	22.13	6.16	18	63	–	–
Age group: 18–47 ($N = 402$)	21.61	4.75	18	46	–	–
Age group: 48–63 ($N = 6$)	52.50	5.75	48	63	–	–
Time spent online	2.41	1.17	0	4	−0.05	−1.06
Perceived threat	15.66	5.37	4	28	−0.10	−0.48
Conspiracy beliefs	25.71	12.21	6	60	0.38	−0.45
Anticipated regret (for vaccination)	2.25	1.51	1	5	0.80	−0.89
Anticipated regret (for non-vaccination)	4.53	2.29	1	7	−0.38	−1.36
Optimism bias	9.20	2.84	2	14	−0.32	−0.22

This measurement was previously used by Meyer et al. (62) to measure vaccination intentions/status.

COVID-19 conspiracy beliefs (exposure variable)

The COVID-19 conspiracy beliefs scale (63) consists of 6 items measured on a 10-point Likert scale ranging from 1 (*do not agree at all)* to 10 (*fully agree*). Example items include "*I believe the pharmaceutical industry is involved in the spread of the coronavirus.*" and "I *believe the coronavirus was intentionally made in a laboratory*." High scores represent a high level of COVID-19-related conspiracy beliefs. The internal consistency indicated by Cronbach's alpha was 0.77.

COVID-19 threat perception (exposure variable)

The COVID-19 Threat Perception Scale (21) was used to measure threat perception. The instrument contains four items (i.e., "*To what extent are you currently worried about the spread of coronavirus*?", and "*To what extent do you currently feel threatened by the spread of coronavirus*?") measured on a 7-point Likert scale, ranging from 1 (*not at all*) to 7 (*very much*). High scores indicated a high level of perceived threat reported by the participants. The internal consistency indicated by Cronbach's alpha was good at 0.80. The instrument was previously used in a Romanian adult sample by Maftei and Holman (43), who reported a similar internal consistency (Cronbach's $\alpha = 0.86$).

COVID-19 optimism bias (exposure variable)

We used two items to measure optimism bias, following the same procedure previously used by Wolff (32). The items measured relative perceived susceptibility and relative perceived probability of a serious prognosis: "*Compared to other Romanians of your age, what is the probability that you will be infected with COVID-19*?" and "*Compared to others Romanians of your age, what is the probability that you will experience severe symptoms following infection with COVID-19*?." We used a 7-point Likert scale ranging from 1 (*extremely low*) to 7 (*extremely high*). To obtain the total score for this variable, we first reversed the items and then calculated the sum of the scores, with high scores representing a high level of optimism bias. Internal consistency indicated by Cronbach's alpha was 0.74.

COVID-19 vaccination anticipated regret (exposure variable)

We measured the anticipated regret for vaccination (i.e., *If I vaccinate against COVID-19, I might regret it*) and anticipated regret for not vaccinating (i.e., *If I don't vaccinate against COVID-19, I might regret it*), using the two items previously used by Wolff (32). We used a 7-point Likert scale ranging from 1 (*very unlikely*) to 7 (*very likely*). High scores represented high levels of anticipated regret for vaccination and anticipated regret for not vaccinating. Subsequent regret was introduced to measure the regret of people who had already been vaccinated against COVID-19. A single item measured this (e.g., "I got vaccinated against COVID-19, and I regret it") using a 7-point Likert scale ranging from 1 (*absolutely not*) to 7 (*extremely much*). High scores indicated a high level of regret of subsequent vaccination.

Time spent online (exposure variable)

Participants' time spent online was measured using an item targeting the number of hours spent daily online, and the answer options were coded from 1 to 5, where 1 means 0–1 h, 2 means 1–3 h, 3 means 3–5 h, 4 means 5–7 h, and 4 means over 7 h. Thus, the higher the score, the higher the time spent online.

Finally, a demographic scale was used to assess participants' gender (self-reported), age, and education level. Using the forward-backward translation strategy, the scales were translated from English to Romanian (64). The minimal differences between the original and back-translated versions were reconciled, resulting in the final versions of each instrument.

Statistical analysis

We used the SPSS 26.0 program to analyze our data. First, we computed the Skewness and Kurtosis values for our variables to assess the normality of the distributions (65), and we further used parametric tests (see Table 1a for the descriptive statistics of the variables).

We also computed the means and standard deviations for the main variables considering the participants' vaccination intention/status (see Table 1b).

Next, we examined the associations between the main variables (see Tables 2a–d), considering the vaccination status of the participants. Additionally, we also explored the potential gender differences concerning the primary variables in our study. Finally, we conducted One Way and Univariate ANOVA analyses to explore the potential interaction effects between gender and vaccination status concerning optimism bias, the perceived COVID-19 threat, and COVID-19 conspiracy beliefs.

Results

Participants who excluded the possibility of vaccinating against COVID-19 ($N = 54$)

In the case of participants who definitely excluded the possibility of vaccinating against COVID-19, the only significant

TABLE 1b Descriptive statistics for the main variables depending on participants' vaccination intention/status.

Variable	Vaccination intention/status			
	Definitely not ($N = 54$), M (SD)	I will consider it ($N = 69$), M (SD)	I will definitely get a vaccine ($N = 15$), M (SD)	I already got a vaccine ($N = 270$), M (SD)
Optimism bias	9.38 (3.47)	8.84 (3.00)	8.60 (3.58)	9.30 (2.61)
Perceived threat	14.14 (6.32)	15.11 (5.42)	17.26 (5.72)	16.02 (5.08)
Conspiracy beliefs	36.96 (11.27)	30.07 (10.91)	29.14 (14.84)	22.15 (10.74)

TABLE 2a Associations between the main variables ($N = 54$, participants who exclude vaccination).

Variable	1	2	3	4	5	6
1. Age	–					
2. Time spent online	−0.17	–				
3. Perceived threat	−0.04	0.04	–			
4. Conspiracy beliefs	0.22	0.09	0.17	–		
5. Anticipated regret (for vaccination)	0.08	0.15	0.11	−0.00	–	
6. Anticipated regret (for non-vaccination)	0.05	−0.05	0.07	0.10	−0.12	–
7. Optimism bias	0.02	0.10	−0.48**	−0.14	−0.08	−0.25

**$p < 0.01$, two-tailed.

association we observed was between the perceived threat and optimist bias ($r = -0.48$, $p < 0.001$). More specifically, a higher perceived threat was associated with lower optimism bias.

Participants who consider the possibility of vaccinating against COVID-19 ($N = 59$)

In the case of participants who were not vaccinated against COVID-19 but considered the possibility to do that, we found a negative association between the time spent online and age ($r = -0.43$, $p < 0.001$), and, as in the case of the first group (i.e., participants who excluded the possibility of vaccinating against COVID-19), higher optimism bias was associated with lower perceived COVID-19 threat ($r = -0.44$, $p < 0.001$). We also found positive associations between the time spent online and the perceived threat ($r = 0.26$, $p = -0.03$) and between anticipated vaccination regret and conspiracy beliefs ($r = 0.44$, $p < 0.001$). Thus, the higher the time spent online, the higher the perceived threat, and the higher the anticipated regret, the higher the conspiracy beliefs. Finally, optimism bias was negatively related to anticipated vaccination regret ($r = -0.35$, $p = 0.003$). Thus, the higher the optimism bias, the lower the anticipated regret.

Participants who will definitely get vaccinated against COVID-19 ($N = 15$)

In the case of participants who were not vaccinated but reported their absolute intention to get vaccinated against COVID-19, we found positive associations between the perceived COVID-19 threat and age, $r = 0.55$, $p = 0.03$, i.e., the older the participants, the higher the perceived COVID-19 threat. Also, our data suggested negative links between the perceived threat and optimism bias ($r = -0.62$, $p = 0.01$), meaning that participants who perceived a higher COVID-19 threat also reported lower optimism bias. Next, we found that the higher the age, the higher the COVID-19 conspiracy beliefs ($r = 0.56$, $p = 0.02$) and the anticipated vaccination regret ($r = 0.57$, $p = 0.02$). In other words, older participants also reported higher conspiracy beliefs and anticipated vaccination regret. Furthermore, the results suggested that optimism bias was negatively associated with vaccination regret ($r = -0.63$, $p = 0.01$), i.e., the higher the optimism bias, the lower the regret.

Participants who already got vaccinated against COVID-19 ($N = 270$)

In the case of participants who were vaccinated, our data suggested that age was negatively related to optimism bias ($r = -0.12$, $p = 0.04$) and the time spent online ($r = -0.28$, $p < 0.001$). In other words, in this group, older participants reported lower optimism bias and lower time spent online. Furthermore, a higher perceived COVID-19 threat was negatively associated with optimism bias ($r = -0.32$, $p < 0.001$), i.e., the higher the perceived threat, the lower the optimism bias. Finally, in this group, higher post-vaccination regret was associated with higher conspiracy beliefs ($r = 0.37$, $p < 0.001$).

TABLE 2b Associations between the main variables ($N = 59$, participants who consider the possibility of vaccinating against COVID-19).

Variable	1	2	3	4	5	6
1. Age	–					
2. Time spent online	−0.43**	–				
3. Perceived threat	−0.05	0.26*	–			
4. Conspiracy beliefs	0.09	−0.11	0.00	–		
5. Anticipated regret (for vaccination)	−0.12	−0.06	0.11	0.44**	–	
6. Anticipated regret (for non-vaccination)	0.09	0.08	0.13	−0.08	−0.12	–
7. Optimism bias	0.00	−0.13	−0.44**	−0.19	−0.23	−0.35*

*p < 0.05, two-tailed. **p < 0.01, two-tailed.

TABLE 2c Associations between the main variables ($N = 15$, participants who will definitely vaccinate against COVID-19).

Variable	1	2	3	4	5	6
1. Age	–					
2. Time spent online	0.14	–				
3. Perceived threat	0.55*	0.13	–			
4. Conspiracy beliefs	0.56*	0.13	0.13	–		
5. Anticipated regret (for vaccination)	0.57*	−0.17	0.38	0.61*	–	
6. Anticipated regret (for non-vaccination)	−0.29	−0.33	−0.20	−0.05	−0.24	–
7. Optimism bias	−0.51	0.17	−0.62*	−0.37	−0.63*	0.35

*p < 0.05, two-tailed.

One-way ANOVA test results

We further conducted Anova One Way analyses to determine the potential differences based on vaccination intentions/status regarding optimism bias and the perceived COVID-19 threat. The analyses were performed using these variables since they comprised the common factor for the four analyses. The results suggested no significant differences between the groups when discussing optimism bias, $F_{(3,404)} = 0.78$, $p = 0.50$. However, we found marginally significant differences concerning the perceived COVID-19 threat, $F_{(3,404)} = 2.55$, $p = 0.055$. However, *post-hoc* Bonferroni analyses did not reveal any subsequent significant differences (all p-s > 0.05).

Next, we aimed to examine how conspiracy beliefs might predict participants' anticipated regret for vaccinating, anticipated regret for non-vaccination, or subsequent regret (following vaccination) in each group when moderated by age. We aimed to select the groups in which we previously observed significant links between these variables (that would further allow moderation analyses), i.e., the participants who consider the possibility of vaccinating against COVID-19 ($N = 59$) and participants who will definitely vaccinate against COVID-19, $N = 15$. However, given the number of participants in these groups, these analyses were not considered reliable (due to a very low statistical power level).

Finally, we explored the potential interaction effect between gender and vaccination status regarding optimism bias, the COVID-19 threat, and conspiracy beliefs. The results of the ANOVA Univariate analyses are summarized in Table 3. Our data suggested no interaction effects in any of the cases (all p-s > 0.05). Regarding optimism bias, the results suggested no significant main nor interaction effects, all p-s >0.05. Regarding the perceived COVID-19 threat, our data indicated that the only significant results were related to the main effect (and not the interaction effect) of gender, $F_{(8,407)} = 4.34$, $p= 0.01$, as well as vaccination status, $F_{(8,407)} = 2.84$, $p = 0.03$. However, the effect sizes were small in both cases, i.e., $\eta^2 = 0.02$ for both gender and vaccination status. Finally, regarding conspiracy beliefs, we found a large effect ($\eta^2 = 0.15$) of vaccination status, $F_{(8,407)} = 23.57$, $p < 0.001$, but no interaction effect ($p = 0.68$).

Discussion

The catastrophic wave in the fall of 2021 drove Romania to the top of the list of dangerous COVID-19 infections, with the highest mortality rate in Europe. At the same

TABLE 2d Associations between the main variables ($N = 270$, participants who were already vaccinated against COVID-19).

Variable	1	2	3	4	5
1. Age	–				
2. Time spent online	−0.28**	–			
3. Perceived threat	0.04	0.01	–		
4. Conspiracy beliefs	−0.06	−0.02	0.07	–	
5. Subsequent regret (for vaccination)	0.00	−0.04	−0.02	0.37**	–
6. Optimism bias	−0.12*	0.06	−0.32**	−0.10	−0.07

*$p < 0.05$, two-tailed. **$p < 0.01$, two-tailed.

time, Romania had one of the lowest vaccination rates. In this context, the present research aimed to explore the link between vaccination intention/status, optimistic bias, COVID-19 conspiracy beliefs, the time spent online, and vaccination (anticipated) regret.

Optimism bias and COVID-19 vaccination

Our results suggested a significant negative association between optimism bias and the perceived threat in all four groups of participants. This result is consistent with those suggested by Garrett et al. (66), according to which optimism bias no longer appears when the perceived threat level is optimal, thus allowing a more accurate risk assessment or diminishing when an immediate threat is present in the environment. For example, Wise et al. (29) examined how a higher involvement in prevention behaviors is preceded by an increase in perceived personal risk and, respectively, a decrease in optimism bias.

Regarding the status and intentions to vaccinate against COVID-19, our results suggested that participants with a high level of the perceived threat and a low level of optimism bias seem to be more likely to get vaccinated, in line with previous studies in this area [e.g., (12, 15, 43)]. Furthermore, the present findings also align with a study carried out in Poland at the beginning of the pandemic [i.e., (67)], which evaluated participants' beliefs in three distinct moments regarding personal chances of personal contracting the virus. Dolinski and their collaborators observed a decrease in optimism bias and an intensification of the perceived personal risk among women the week after the announcement of the first COVID-19 infection due to the increase in the perceived threat level (67). Thus, our results seem to align with the general overview regarding the inversely proportional association between optimism bias and perceived threat regarding engagement in prevention behaviors such as COVID-19 vaccination.

Optimism bias and the anticipated regret for vaccination

Furthermore, we found a significant negative association between the optimism bias and the anticipated regret for vaccination in the group of participants who reported they would definitely get vaccinated, which is a novelty brought by the present study, given its focus on four separate participant groups. Anticipated regret was suggested as a significant predictor of vaccination intention in several previous studies [e.g., (51, 68, 69)]. Also, according to the results of a study that aimed to examine the main factors of vaccine hesitancy from the perspective of HBM and TPB, anticipated regret was the most significant predictor of vaccination, with a high score of anticipated vaccination regret indicating a more negative attitude toward of vaccination (12).

However, when Chen and Yeh (70) examined the factors affecting the intention to engage in preventive behaviors, they did not find a significant moderating effect of optimism bias on anticipated action regret. Furthermore, according to the results presented by Wolf (32), anticipated regret for vaccination seems to be lower than anticipated regret for not vaccinating, and optimism may not predict vaccination intention. These explanations could support the non-significant associations obtained between optimism bias and anticipated regret in terms of participants who excluded vaccination and those who reported the possibility of getting vaccinated in the future. At the same time, Khayyam et al. (51) suggested that the perceived susceptibility to contracting COVID-19 mediated participants' regret concerning COVID-19 vaccination. Thus, these findings highlight the possibility of other variables influencing the associations between anticipated regret and vaccination and optimism bias and vaccination. Nevertheless, our results also indicated a negative association between optimism bias and anticipated regret, depending on vaccination intentions and status, which can be observed in various research and cultural contexts.

TABLE 3 Univariate ANOVA test results for optimism bias, perceived threat, and conspiracy beliefs (vaccination status × gender).

Optimism bias		Vaccination status × gender M (SD)	Test of between-subject effects			
Vaccination status	**Gender**					
Group 1 ($N = 54$)	Female	9.27 (3.34)		$F_{(8,407)}$	p	η^2
	Male	9.81 (4.09)	Vaccination Status	0.52	0.66	0.004
Group 2 ($N = 69$)	Female	8.55 (3.02)	Gender	1.90	0.15	0.009
	Male	9.55 (2.91)	Vaccination status × gender	0.55	0.64	0.004
Group 3 ($N = 15$)	Female	7.75 (3.49)				
	Male	9.57 (3.69)				
Group 4 ($N = 270$)	Female	9.23 (2.62)				
	Male	9.48 (2.58)				
Perceived threat		**Vaccination status × gender M (SD)**	**Test of between-subject effects**			
Vaccination status	**Gender**					
Group 1 ($N = 54$)	Female	9.27 (3.34)		$F_{(8,407)}$	p	η^2
	Male	9.81 (4.09)	Vaccination Status	2.84*	0.03	0.02
Group 2 ($N = 69$)	Female	8.55 (3.02)	Gender	4.34*	0.01	0.02
	Male	9.55 (2.91)	Vaccination status × gender	0.83	0.47	0.006
Group 3 ($N = 15$)	Female	7.75 (3.49)				
	Male	9.57 (3.69)				
Group 4 ($N = 270$)	Female	9.23 (2.62)				
	Male	9.48 (2.58)				
Conspiracy beliefs		**Vaccination status × gender M (SD)**	**Test of between-subject effects**			
Vaccination status	**Gender**					
Group 1 ($N = 54$)	Female	9.27 (3.34)		$F_{(8,407)}$	p	η^2
	Male	9.81 (4.09)	Vaccination status	23.57**	0.00	0.15
Group 2 (N=69)	Female	8.55 (3.02)	Gender	0.40	0.67	0.002
	Male	9.55 (2.91)	Vaccination status × gender	0.49	0.68	0.004
Group 3 ($N = 15$)	Female	7.75 (3.49)				
	Male	9.57 (3.69)				
Group 4 ($N = 270$)	Female	9.23 (2.62)				

Optimism bias and anticipated regret for not vaccinating

We also found a significant association between optimism bias and anticipated regret for not vaccinating in participants who considered getting vaccinated. The association between optimism bias and anticipated regret for not vaccinating has not been studied in the past in a similar context, and its analysis is a novelty of the present work. However, anticipated regret for not vaccinating was an important predictor of anti-COVID-19 vaccination intention in several studies (32, 71, 72). A significant example in this regard is represented by a longitudinal study on the Israeli population that analyzed several possible factors that might impact the intention to vaccinate against COVID-19 [i.e., (52)]. The results presented by the authors suggested that anticipated regret for not vaccinating might be a better predictor of vaccination intention than anticipated regret (52). Consistent with this idea, similar patterns were also observed in other contexts, such as HPV vaccination, where the anticipated regret for not vaccinating was also a significant predictor of vaccination intention (54, 55, 73).

Previous studies also suggested that people with a high level of anticipated regret for not vaccinating and a high level of optimism might be more likely to vaccinate (15, 52). At the same time, other studies suggested that anticipated regret was not a significant predictor of vaccination intention [e.g., (74)]. Furthermore, Wolff (32) suggested that anticipated regret for not vaccinating negatively predicted intention to vaccinate, this result being attributed to the idea that the lower the

disadvantages of not vaccinating, the less socially accepted the side effects of vaccination will be. These findings might support and also explain the non-significant associations we found between optimism bias and anticipated regret for not vaccinating in the case of participants who excluded vaccination or were absolutely sure about their intention to vaccinate against COVID-19.

Optimism bias and subsequent vaccination regret

Our findings also suggested no significant negative association between optimism bias and subsequent vaccination regret among participants who have already been vaccinated. This result might be explained by the fact that people interested in vaccinating against COVID-19 might have a higher desire to protect their family and community (75). Thus, even if individuals have a high optimism bias and perceive a low risk of infection for themselves, they may have been vaccinated to protect those around them, assessing the risk of others as higher. At the same time, this desire of people to protect their close ones could be amplified by the fact that participants with a high level of optimism bias evaluate their own risk of infection much higher for an acquaintance than for themselves, considering the possibility of being infected soon as more temporally distant for oneself than for other individuals (27). Furthermore, the perceived benefits might also be an additional significant predictor of intentions to vaccinate against COVID-19, as suggested by previous studies (52, 74). Therefore, a high level of perceived benefits may eliminate subsequent vaccination regret for people with a high level of optimism bias. More specifically, the non-significant association obtained between optimism bias and subsequent regret for vaccination could be due to a cause such as individuals' desire to protect their loved ones or the existence of a high level of perceived benefits. However, these potential explanatory mechanisms need to be explored in further studies.

At the same time, another pattern suggested by the present results was related to the positive link between anticipated regret, post-vaccination regret, and conspiracy beliefs. The pandemic is not over yet; according to WHO (1), new waves are coming with modified versions of the SARS-CoV-2 [The European Centre for Disease Prevention and Control (76)]. However, it seems that an adapted series of vaccines against the BA.4, BA.5, and BA.1 variants of the Omicron are waiting for approval, so we might likely have to re-vaccinate (76). In this context, exploring the underlying mechanisms regarding anticipated and subsequent regret concerning COVID-19 vaccination, especially those related to conspiracy beliefs, is essential.

Optimism bias and time spent online

Our results suggested no significant positive association between optimism bias and time spent online across all four participant groups. This result is consistent with the results obtained in a study that analyzed the association between optimism bias and various factors in the context of the H1N1 flu; the authors observed an insignificant relationship between optimism bias and social media (77). In addition, previous studies suggested that being constantly exposed to the news was associated with a lower optimism bias in the context of perceived personal risk. In contrast, exposure to COVID-19-specific information was associated with a high optimism bias (78). At the same time, the negative news about COVID-19 vaccines presented on social media and low trust in the health system was associated with a lower level of vaccine acceptance (79). Furthermore, social media use seems also to be more strongly associated with conspiracy beliefs about the SARS-CoV-2 virus when conspiratorial thinking is heightened (80). Thus, the non-significant association observed in our study between the optimism bias and the time spent in the online environment could be explained by the fact that the media content watched would have a decisive role in this regard, and some people are predisposed to follow the information that aims to distort because of a high level of conspiratorial thinking. Thus, it is highly important to explore further the specific media contents that people are generally exposed to regarding health matters, to understand better the link between time spent online, which could also mean engagement in various activities such as academic or personal research, work-related activities, friends' online social gathering.

Vaccination group differences

A novelty of the present study is also related to the fact that it also examined the differences between participants who excluded vaccination and participants who considered this option, those who were sure they would vaccinate, and those who have already been vaccinated in terms of the optimism bias, the perceived threat, and conspiratorial beliefs, differences that have not yet been explored in the context of the COVID-19 pandemic, to our knowledge (at least not in Romania). According to our results, there were no significant differences in optimism bias between any of the groups. These non-significant results are similar to some of the previous findings, according to which optimism bias was not a significant predictor of COVID-19 vaccination intentions (31, 32). A non-significant association between optimism bias and vaccination intention or adherence to preventive behaviors has also been observed for the H1N1 virus (77, 81). A possible explanation of these

results could be related to the fact that a high perception of risk in close people could have influenced adherence to prevention behaviors such as vaccination. For example, exposure to friends' vaccination-related posts is positively associated with vaccination intention through positive affective responses (46). In addition, some people might resort to vaccination even if the level of perceived personal risk is low to protect the people around them (75).

Also, people seem to be more inclined to adhere to preventive behaviors if they understand that they are at risk, as measured by the susceptibility and perceived severity of the virus (11). However, a study that included participants with clinical conditions observed that while they showed a comparatively unrealistic optimism about their own infection compared to infecting others, this effect was not found for the risk of severe symptoms. Thus, it might be possible that some people show an optimism bias for perceived personal susceptibility but not for severity (82). Nevertheless, the optimism bias may have also been influenced by other aspects such as perceived risk from others, the desire to protect others, gender differences, or differences in perceived personal susceptibility or severity, which could be explored in future studies.

Furthermore, we found no significant differences in perceived threat between any groups. Comparative results were also obtained in a study that analyzed the hesitation of mothers regarding vaccination and the perceived threat influencing adherence to preventive behaviors such as wearing a mask but not the intention to vaccinate (83). Similarly, Bodas et al. (84) suggested that, while perceived threat did not predict vaccination intention, the importance of vaccination and perceived vaccine effectiveness were significant predictors (84).

An alternative explanation for our results could be related to the introduction of green certificates and restrictions for vaccinated people. The *green certificate* is a document that certifies that a person has either been vaccinated against COVID-19 or has had COVID-19 and recovered from the disease. In the European Union, during the coronavirus pandemic, a series of restrictions were introduced for people who did not hold such a certificate, such as travel restrictions, participation in various group events, or activities in closed spaces such as going to the cinema or gym. According to analyzes of vaccination rates following the introduction of these green certificates, there was an increase of 13 % in France, 6.2 % in Germany, and 9.7 % in Italy in terms of vaccination levels in the population after the introduction of green certificates (85). In Romania, starting October 10, 2021, following the adoption of Government Decision no. 1,090/2021, the daily vaccination rate increased from 52,815 vaccines administered on 9.10.2021 to 71,605 vaccines administered on 10.11.2021 according to the National Committee for the Coordination of Activities on Vaccination against COVID-19 (3). Thus, the non-significant differences obtained between participants who excluded vaccination and the other three groups of participants who were considering vaccination or have already done so in terms of perceived threat could be because perceived vaccine efficacy might be an important factor in the decision to vaccinate or could be caused by restrictions implemented by the state for unvaccinated people.

We also found significant differences between participants who excluded vaccination and participants who expressed the possibility of getting vaccinated in the future in terms of conspiracy beliefs, with the mean of people who excluded vaccination being significantly higher. These results are consistent with previous findings suggesting that conspiracy beliefs are a significant negative predictor of vaccination intention (39, 40, 42).

Contrary to our expectations, no significant differences were observed between participants who excluded vaccination and those who were sure they would vaccinate in terms of conspiracy beliefs. According to the previous research exploring the relationship between conspiratorial beliefs and vaccination intention, when the subjective norm is high (i.e., when the participants perceived that others close to them approved of vaccines), conspiratorial mentality no longer predicts vaccination intentions (86). Furthermore, estimated social norms were also positively associated with participants' intentions regarding the importance of getting a COVID-19 vaccine (87). Moreover, perceived disease risk and vaccine dangerousness have been observed to be mechanisms by which conspiracy theories can discourage vaccination (37). Thus, there may be other aspects that can influence vaccination statuses, such as vaccine efficacy or social norms, which can be discussed and examined in future studies.

Gender differences

Finally, we found that the female participants from the group of participants who did not get a vaccine but considered the possibility scored higher than males on the perceived COVID-19 threat. Also, the female participants from the group of participants who were already vaccinated against COVID-19 scored higher than males on the perceived COVID-19 threat. These results align with previous findings that reported that women are generally more likely to report high levels of threat and fear of COVID-19 [e.g., (88)], as well as other similar infectious disease outbreaks [e.g., H1N1 (89); SARS-CoV-1 (90)]. Thus, our findings add to the literature that generally suggests that women are more likely to engage in preventive behaviors than men [e.g., (91)].

At the same time, female participants also scored higher than males regarding the COVID-19 conspiracy beliefs in the already vaccinated participants. This result contradicts previous findings from the early stages of the pandemic suggesting the opposite, i.e., males are more prone to COVID-19 conspiracy beliefs

[e.g., (92)] or following the development of COVID-19 vaccines [e.g., (63)], as well as other studies suggesting that COVID-19 conspiracy operates similarly in men and women (93). However, our results also align with similar findings [e.g., (94)], highlighting the mixed data in this area and the need for future research to better clarify these potential gender differences. These results are important since they have implications for public health campaigns, given their useful input in shaping effective preventive health strategies, not only for COVID-19 but for future similar health crises.

Implications of the present results

One of the novelties of this paper is that it explored the association between optimism bias and several key variables associated with vaccination intention, such as perceived threat and anticipated regret. In several previous empirical approaches, optimism bias was suggested as a possible predictor or explanatory mechanism of the intention to vaccinate (95–97), but the present results contribute to filling some gaps about these possible influences depending on participants' vaccination status, in a particular threatening context.

Considering that Romania was in the top 10 countries in Europe with the lowest vaccination rates against COVID-19, it is all the more important to investigate the underlying factors of Romanians' decision to get vaccinated (or not) to be able to act more effectively in future similar health-threatening situations. In addition, our results also highlighted the need for accurate information regarding the deadly nature of the virus, its severity, and the effectiveness of the COVID-19 vaccines to limit the influence of the COVID-19 infodemic and related deaths.

Limitations and future directions

The present work has several limitations that need to be addressed. First, we used a convenience sample, and the number of participants was relatively low, which lowered the generalizability of the present findings (98). Furthermore, our sample was formed by young adults, which should also be considered when interpreting the present findings. For example, several previous studies highlighted the significance of age differences when discussing optimism bias regarding health-related behaviors [e.g., (25, 99)], as well as COVID-19 risk perception and preventive behaviors [e.g., (100)]. At the same time, the sample was unbalanced concerning the vaccination status, limiting both the generalizability and a more in-depth exploration regarding the possible moderating effects that we observed (i.e., the potential moderating role of age on the link between COVID-19 conspiracy beliefs and participants' anticipated regret for vaccinating, anticipated regret for non-vaccination, or subsequent regret—following vaccination). These concerns should be addressed in further studies using extended and more balanced samples of participants.

Also, it is important to mention that multivariate analysis was not conducted due to the skewed distribution of the vaccination intention/status variable, where some categories did not have large enough cell size distributions across exposures (COVID-19 conspiracy beliefs, COVID-19 threat perception, COVID-19 optimism bias, COVID-19 vaccination anticipated regret, and time spent online) and covariates (gender, age, and education level). Future studies might address this limitation by performing, for example, multivariate Ordinary Least Squares (OLS) or logistic regression using large enough cell size distributions.

Another limitation was the method of collecting the answers (i.e., online) and the self-reported character of the scales we used, which might have encouraged desirability. Also, optimism bias was only measured by the perceived personal risk of contracting SARS-CoV-2 but not the perceived threat to other people, and future studies might account for this in future approaches. Finally, another limitation could be represented by how we measured conspiratorial beliefs since we did not measure conspiratorial beliefs related to the vaccine's effectiveness or the dangers associated with it, but only conspiratorial beliefs related to the virus itself.

Future research could also explore the differences between those who have already been vaccinated and those who have not been vaccinated in terms of the perceived COVID-19 vaccine efficacy and risk, as these variables were important predictors in several studies and were not analyzed in the present work (14, 54, 79). In addition, future research might explore whether the restrictions adopted by the authorities and the introduction of the green certificate influenced the vaccination behavior of Romanians to some extent.

To conclude, the present study highlighted the significant association between optimism bias and some central variables within HBM and TBP theoretical models, such as the perceived threat and anticipated regret in the context of Anti-COVID-19 vaccination. Moreover, several significant differences depending on participants' vaccination intentions and status concerning the conspiracy beliefs highlighted the need for further studies in this area, especially given the uncertainty about the evolution of the COVID-19 pandemic.

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 Faculty of Psychology and Educational Sciences, Alexandru Ioan Cuza University. The patients/participants provided their written informed consent to participate in this study.

Author contributions

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

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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COVID-19 risk, attitudes and behaviour study (CRAB study): A knowledge, attitudes, and practise qualitative study of COVID-19 in the Royal Navy

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Introduction: Outbreaks of SARS-CoV-2 onboard maritime platforms spread rapidly and have high attack rates. The aim of the COVID-19 Risk, Attitudes and Behaviour (CRAB) study was to investigate the knowledge, attitudes, and practises in the Royal Navy in relation to COVID-19 prevention.

Methods: The CRAB study was a cross-sectional survey, using a census sampling method, conducted in May and June 2021. An online questionnaire was distributed to all serving Royal Navy regular personnel using either the MyNavy application or *via* a QR code through email for a continuous 14 day period. The questionnaire was based on an existing validated questionnaire used for avian influenza epidemics. Questions investigated individual perceptions of COVID-19 seriousness, compliance with prevention methods, explored vaccination intention and vaccine hesitancy (unvaccinated individuals who declined or were unsure about receiving a COVID-19 vaccine). The chi-squared test of best fit was used to compare the demographic responses against the whole organisation, with p-value < 0.05 deemed significant. Odds ratios were used to investigate associations between demographic groups and responses to questions, with an odds ratio crossing 1.0 deemed non-significant.

Results: The response rate was 6% (2,080/33,200), with 315 responses collated in the pilot phase and 1,765 in the main study phase. Male participants were less likely to rate COVID-19 as serious (OR 0.34; 95% CI: 0.23–0.49). BAME ethnicity (OR 2.41; 95% CI: 1.12–5.17) rated it as more serious. At the time of the study 62% of respondents had received one dose of a COVID-19 vaccine.

In the 797 unvaccinated personnel, vaccine hesitancy accounted for 24.2% (193/797), of whom 136 were white males. Those who had a higher COVID-19 serious rating, the most significant factor for non-adherence to COVID-19 prevention measures in both vaccinated (OR 1.61 [95%CI: 1.20–2.17]) and vaccine-hesitant (OR 3.24 [95%CI: 1.63–6.41]) individuals was colleagues' non-adherence. The most trusted source of information on vaccines was provided by the Defence Medical Services (77.2% [1,606/2,080]).

Conclusion: This study has identified reasons for COVID-19 protective measure adherence, sources of information trusted by respondents and vaccine hesitancy, in the Royal Navy. The questionnaire can be used to investigate attitudes and behaviours in future emerging infectious diseases.

KEYWORDS

COVID-19, Navy, survey, military, vaccine hesitancy

1. Introduction

The first reported cases of COVID-19 diagnosed in the United Kingdom (UK) was on 27 January 2020 (1) and the World Health Organisation (WHO) declared COVID-19 a global pandemic on 11 March 2020 (2). It is well recognised that viral respiratory infections have high attack rates onboard maritime platforms (3–5) as documented in early civilian and military outbreaks on ships (6–9). The Royal Navy quickly adopted a quarantine and isolation policy consisting of 14-day isolation in single ensuite accommodation and SARS-CoV-2 polymerase chain reaction (PCR) testing on day 0, 7, and 12. This policy was able to mitigate some of the risk of exposure and onward transmission, although once the virus was onboard a vessel, large outbreaks were typically observed (6–9).

Early control measures were largely based in identifying and isolating contacts as well as reducing social mixing through lockdown measures. The four nations of the UK went into a full lockdown, with only essential movement of people, on 3 occasions, with the last lockdown in England ending fully by 19 July 2021 (10). The compliance with National Health Service (NHS) Test and Trace and COVID-19 lockdowns was unknown in UK Armed Forces personnel during the COVID-19 pandemic. Adherence to the NHS Test and Trace has been reported at 18.2% between March and September 2020 (11), with up to 75% of household contacts of positive cases leaving home (11). The drop in compliance to NHS Test and Trace quarantine, was observed just as national guidance for self-isolation for testing positive to SARS-CoV-2 was reduced from 14- to 10-days (10).

Previous studies regarding the SARS-CoV-2 virus and associated risk-taking behaviours and attitudes have been conducted among civilian populations, investigating factors leading to an increase in preventative behaviours during the early phase of the pandemic. Increasing age, higher educational attainment, female sex and perceived fear have been identified the most protective factors (11–15). Socio-economic factors that appear to appear to demonstrate better compliance to COVID-19 preventative behaviours are education and occupation (13, 15). Higher education status particularly linked to higher knowledge of the disease and therefore better compliance (14). Those with higher education are also likely to be in more senior occupational roles (14) and therefore consider not just the impact of the disease on them but also their work. Those individuals who are compliant are most likely to be compliant to all the guidelines, rather than just some (14). Older age were also more likely to adopt COVID-19 compliance measures (15).

Prior to this study, little was known about these factors among military personnel. In general, risk-taking behaviour in UK Armed Forces personnel, who are predominantly male and younger age is variable, with increases in impulsive-sensation seeking behaviour in combat arms, especially when controlled for age and gender (16, 17).

The UK was one of the first nations to licence rapidly developed SARS-CoV-2 vaccinations and to implement a national vaccination programme, which started in December 2020 (18). UK Armed Forces personnel were voluntarily vaccinated through the national programme, with older and higher risk populations vaccinated first. Individuals were provided with the same information about the safety and efficacy of the vaccines as the civilian UK population, as well specific information endorsed by the UK Surgeon General which further detailed military-specific information regarding the safety, efficacy, occupational risks, deployability, and vaccination rollout. Individual members of the military were given time to book and attend their vaccination through NHS vaccination centres, with transportation arranged for those in remote locations or unable to travel independently. The national vaccination rollout for adults

below the age of 40 years occurred concurrently with the CRAB study.

Conflicting social media messaging, such as misinformation about vaccine-induced infertility, reduced confidence in COVID-19 vaccine safety which is reported to have increased vaccine hesitancy in younger populations (19). The 5C model is one of several models developed to predict vaccine intention and behaviours (20). The five components of this model consist of: Confidence (trust and effectiveness of vaccines), Complacency (perceived risk and threat of vaccine-preventable diseases), Constraints [Convenience] (psychological and physical barriers to vaccination), Calculation (individual data gathering), and Collective Responsibility (individual willingness to protect others by getting vaccinated) (20). The 5C model is applicable to military populations due to factors affecting the key predictors such as geographical availability of vaccines, potential direct and indirect restrictions on data gathering and collective responsibility to protect colleagues.

The aim of the CRAB study was to investigate the knowledge of COVID-19, attitudes to COVID-19 preventative measures, motivations to comply with disease control measures, information requirements regarding COVID-19 and attitudes towards COVID-19 vaccination, with further subgroup analysis by demographics, among serving Royal Navy (RN) personnel. We hypothesised that older age, those in a more senior rank, female sex and BAME ethnicity were most likely to adhere to COVID-19 guidelines and have high vaccine uptake.

2. Materials and methods

2.1. Study design and participants

The study used a cross-sectional design and administered an online questionnaire in two phases, consisting of a small pilot phase (17 May to 24 May 2021) followed by the main study phase (24 May to 7 June 2021) (Figure 1). The study was conducted as a census sample, taking a "snapshot" of the whole RN organisation of ~33,000 serving personnel, with an anticipated response rate of 20–25% based on previous studies (12). The proposed response rate was based on the return rate by rank rather than age alone, as returns in lower age groups are considered to be lower than older populations.

The questionnaire was conducted online using the Lime Survey application. Participants accessed the Lime Survey, *via* the MyNavy application or QR codes distributed to each naval/marine shore establishment and afloat unit. Every member of the RN has their own MyNavy account, and approved recruitment messages were distributed *via* the MyNavy administration team. On opening the link, participant information detailed the aims of the study and outlined the voluntary nature and anonymity. The questionnaire was configured not to store any personal information. The pilot phase was opened for 7 days on the 17 May 2021, with over 100 participants asked to reply, from a cross-section of the total study population. Results were scrutinised by the CRAB study steering group for any inconsistencies in responses. The main phase of the study was launched on the 24 May 2021 and remained open for 14 days. A preliminary report of key findings was produced and distributed to the senior RN leadership to assist in policy formation (Figure 1).

2.2. Questionnaire

The questionnaire was based on the Effective Communication in Outbreak Management (ECOM) tool (21), initially designed to assess attitudes and behaviours towards 2009 H1N1 pandemic avian influenza in European urban and ethnic minority groups. The ECOM tool consists of 35 questions using a mix of Likert scale and best-answer questions (21). The ECOM questionnaire was designed following expert panel review, demonstrating good convergent validity ($r = 0.86$), although reliability was not formally assessed, however it did undergo a pilot phase ($n = 29$) and five think-aloud-interviews leading to minor modifications (18). This questionnaire was chosen as the basis of the CRAB questionnaire due to its design. COVID-19 specific questions were added and exiting questions modified. We replaced the "unnamed disease" in the ECOM questionnaire with COVID-19, with the questions modified to compare COVID-19 against other infectious diseases such as influenza and meningitis. Questions were grouped into five areas: knowledge of COVID-19; attitudes to COVID-19 preventative measures; motivations to comply with disease control measures; information requirements regarding COVID-19 and attitudes towards COVID-19 vaccination (Supplementary Figure 1).

Demographic data included age, sex (male/female), rank, ethnicity, and educational attainment. Age was grouped into four categories (16–24, 25–34, 35–44, and >45 years). Ranks were categorised using North Atlantic Treaty Organisation (NATO) rank ranges: R1–R4 (junior ranks), R6–9 (non-commissioned officers [NCO]), OF1–OF3 (junior officers), and OF4+ (senior officers). Ethnicity was based on Census 2021 groupings. Educational attainment was recorded according to UK educational framework levels: Level 2 (GCSEs and Scottish Nationals), Level 3 (A-levels and Scottish Highers), and Level 5 onwards (Bachelor's degree or higher). The RN branch was divided into warfare, Royal Marines (RM), logistics, medical, engineers, aircrew, and others (e.g., chaplains, training management officers and other smaller branches not previously included).

To improve uptake and reduce responder bias, the questionnaire was configured to take <10 min to complete, used non-leading questions which were short and easily interpreted. The more controversial questions were included at the end. The

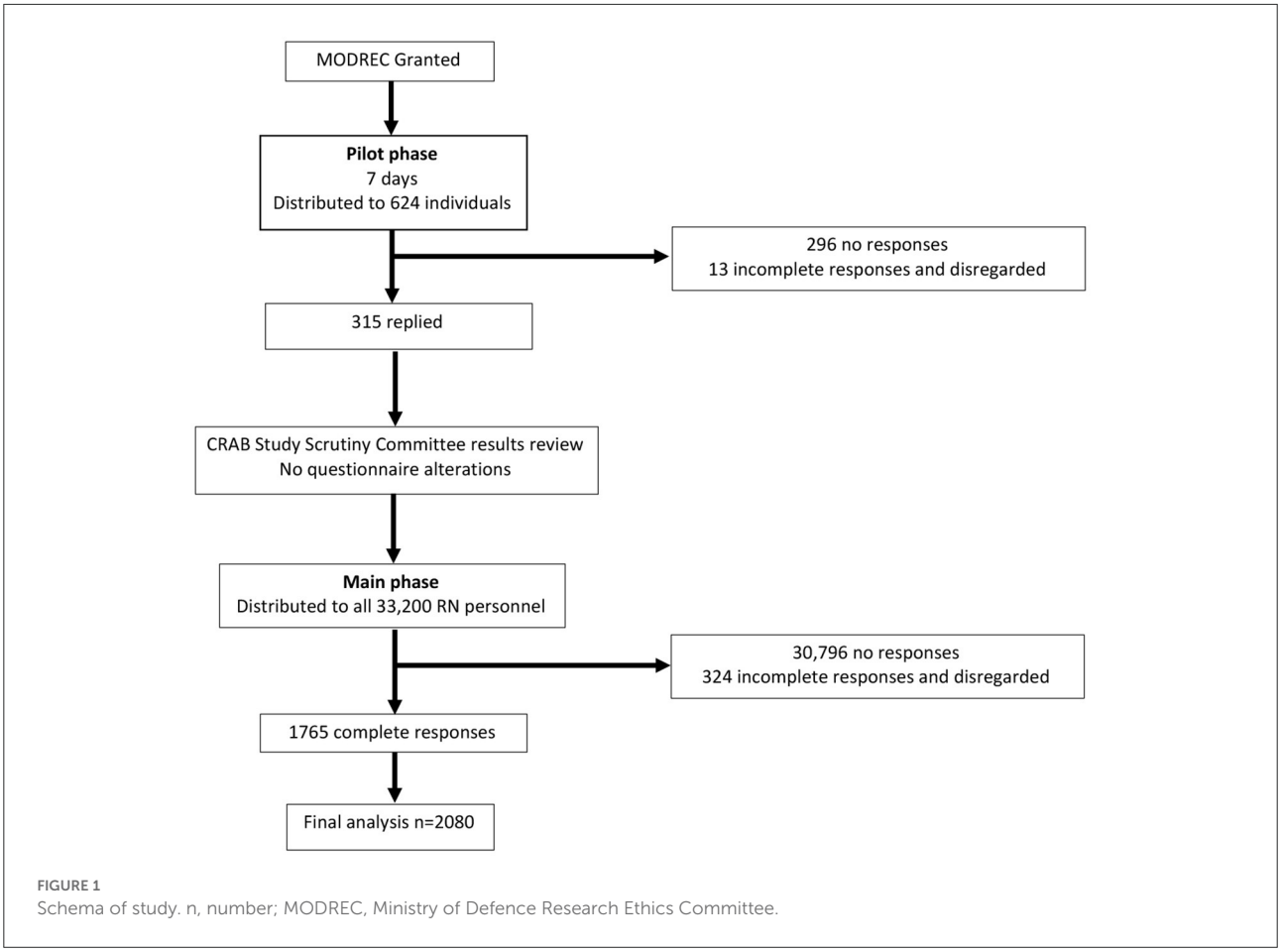

FIGURE 1
Schema of study. n, number; MODREC, Ministry of Defence Research Ethics Committee.

questionnaire was reviewed by two clinical psychologists with substantial experience of questionnaire design.

2.3. Ethics

Full ethical approval was obtained from the Ministry of Defence Research Ethics Committee (2031/MODREC/21).

2.4. Statistical analysis

Data were cleaned using frequency lists to identify invalid characters and missing values. The pilot and main study data were combined for cleaning and analysis. Data were analysed using Stata v17.1 (StataCorp LLC, Texas, US) and R Statistical Software (v3.6.1, R Core Team 2019). Descriptive statistics were used to compare demographics, with medians and interquartile ranges (IQR) used after normality testing. The chi-square goodness of fit test was used to test significance ($p < 0.05$) of the observed proportions against the proportions across the whole organisation. Unadjusted ordinal logistic regression models were used to explore the relationship between demographics (age, sex, ethnicity, rank, educational attainment, and branch) and knowledge of COVID-19, attitudes to COVID-19 preventative measures, motivations to comply with disease control measures, information requirements regarding COVID-19 and attitudes towards COVID-19 vaccination. These are reported as odds ratios (OR) with 95% confidence intervals (CI) with an odds ratio crossing 1.0 deemed non-significant.

3. Results

3.1. Responses and demographics

The total number of responses were 2,080 from 33,200 personnel (response rate of 6.3%). The 16–24- and 35–44-year-old groups were the highest responders ($n = 564/2,080$ and $n = 565/2,080$, respectively, 27%), although that did not match the total proportions in those sub-groups across the whole organisation using chi-squared test of best fit ($p < 0.001$) (Table 1). 1,721 (83%) respondents were male which was a lower proportion than across the total organisation using chi-squared test of best fit ($p < 0.001$). 1,978/2,080 respondents (95%)

TABLE 1 Summary of demographic responses across the organisation.

		No. of survey respondents (*n*)	Percentage of total survey respondents (%)	No. across RN (*n*)	Percentage of the total RN (%)	*P*-value
Age	16–24	565	27	9,080	27	
	25–34	489	23	12,260	37	
	35–44	565	27	8,100	25	
	45+	461	22	3,760	11	
	Total	2,080		33,200		**<0.001**
Biological sex	Male	1,721	83	29,980	90	
	Female	359	17	3,220	10	
	Total	2,080		33,200		**<0.001**
Ethnicity	White	1,978	95	31,710	95	
	BAME	89	4	1,490	5	
	Prefer not to say	13				
	Total	2,080		33,200		0.84
Rank	R1–R4 (Junior rank)	877	42	18,140	54	
	R6–R9 (NCO)	541	26	8,495	26	
	OF1 to OF3	481	23	4,579	14	
	OF4+	181	9	1,986	6	
	Total	2,080		33,200		**<0.001**
Educational attainment*	GCSE or equivalent (Level 2)	638	31			
	A-levels or equivalent (Level 3)	673	32			
	Bachelor's degree or higher (Level 5+)	769	37			
	Total	2,080		33,200		

n, number; BAME, black and minority ethnic groups; R, other ranks; RN, Royal Navy; OF, officer. *An accurate total across the organisation is not available. Test of significance using Chi-square goodness of fit comparing the observed responses compared to proportions across the whole Royal Navy.
The bold values indicated to illustrate significant values to a reader quickly reading the article.

identified as White (English, Welsh, Scottish, Northern Irish, or British), which represents a similar proportion across the Royal Navy using chi-squared test of best fit ($p = 0.84$). According to the 2020 UK Armed Forces biannual diversity statistics 91% of the Royal Navy workforce was male, with 4.6% from a BAME ethnicity (22). By rank, the largest group of responders was the junior rank cohort ($n = 877/2,080$, 42%), which was lower than the proportion across the organisation ($p < 0.001$). The largest cohort by highest educational attainment was Level 5 ($n = 769$, 37%), followed by the Level 3 ($n = 673/2,080$, 32%).

3.2. Knowledge of COVID-19

Most participants (1,548/2,080, 74.4%) rated meningitis as serious (5/6) or extremely serious (6/6), compared to 43.5% (905/2,080) for COVID-19 and 26.9% (560/2,080) for influenza. When considering the level of concern about becoming infected with COVID-19 over the next 12 months, 27.7% of individuals (576/2,080) were somewhat concerned about being infected with COVID-19 with 4.9% (102/2,080) who were very concerned and 22.9% (477/2,080) not concerned at all. Of those who were not concerned, 65% (310/477) were aged ≤35 years and 55% (263/477) were junior ranks (R1–4).

Overall knowledge of COVID-19 symptoms and transmission was high. The majority of responders (2,038/2,080, 98%) understood COVID-19 may be asymptomic, that COVID-19 can be acquired more than once (1,914/2,080, 92%) and that there is a vaccine offering protection from COVID-19 (1,934/2,080, 93%). Subgroup analysis showed that among responders aged ≤35 years 97.8% (1,030/1,054)

knew COVID-19 could be asymptomatic, 98.2% (1,034/1,054) knew COVID-19 can be acquired more than once, and 92.0% (968/1,054) knew there was COVID-19 vaccine offering protection. Among white males under the age of 35 years (n = 796), 1.9% (15/796) thought COVID-19 was only a symptomatic disease, 1.8% (14/796) thought it could only be contracted once and 93.5% (744/796) understood there was a vaccine available. Among this group who did not believe there was a vaccine against COVID-19 (52/796), there were very different perceptions of the seriousness of COVID-19 when compared to influenza and meningitis (Supplementary Figure 1).

3.3. Attitudes to force health protection measures and compliance

When questioned about force health protection measures (FHPM), especially non-pharmaceutical interventions (NPIs) such as facemask wearing, social distancing and regular testing using lateral flow devices (LFDs), many individuals (1,707/2,080, 82.1%), felt isolation of positive and suspected cases reduced the risk of COVID-19, with face coverings being considered the least effective measure (1,429/2,080, 68.7%). Among white male responders who had not received a dose of a COVID-19 vaccine, were unsure or not going to receive a dose (n = 136), most identified isolation of positive cases (41/136, 30.1%) and frequent cleaning (29/136, 21.3%) as the most certain ways to reduce the risk of acquiring COVID-19 (Supplementary Figure 2).

The single greatest motivation to adhere to COVID-19 FHPM was the protection of family (942/2,080, 45.3%), followed by the protection of colleagues (474/2,080, 22.8%). Those who did not want to affect the functioning of their unit and were vaccine hesitant did not perceive COVID-19 to be as serious as those who were vaccinated (OR 0.57 [95%CI: 0.34–0.96]), whereas the most significant factor to motivate NPI adherence in those vaccinated compared to those unvaccinated was concern about being ill as they deemed COVID-19 to be more serious (OR 1.96 [95%CI: 1.47–2.60]).

Factors associated with non-adherence to COVID-19 FHPM were regular LFD testing (819/2,080, 39.4%), and COVID-19 vaccinations (763/2,080, 36.7%). In those who considered COVID-19 to be more serious, the most significant factor for non-adherence to COVID-19 NPIs in both vaccinated (OR 1.61 [95%CI: 1.20–2.17]) and vaccine-hesitant (OR 3.24 [95%CI: 1.63–6.41]) responders was work colleagues' non-adherence to the same FHPM when compared to those who thought measures didn't work. Those who had been vaccinated deemed COVID-19 to be less serious when going to see family (OR 0.69 [95%CI: 0.54–0.88]) and friends (OR 0.62 [95%CI: 0.48–0.82]) when compared to those unvaccinated.

3.4. Information regarding COVID-19

Most individuals trusted their respective medical centre or the Defence Medical Services in providing information regarding the COVID-19 vaccinations (1,606/2,080, 77.2%), followed by UK Government websites (1,573/2,080, 75.6%). Responders considered that religious leaders (22/2,080, 1.1%) and social media (40/2,080, 1.9%) were the least trusted information sources. Information regarding the COVID-19 vaccine (836/2,080, 40.1%) was the most popular topic for requesting further information.

3.5. Intention to vaccinate against COVID-19

Just under two thirds of the study population had received one dose of a COVID-19 vaccine in the first 6 months of the national vaccine rollout (1290/2,080, 62%). Of the remaining 797 participants, 193 (24.2%) showed vaccine hesitancy, declining the vaccine or were unsure about receiving it. Analysis of the perceived seriousness by both age and vaccine hesitancy showed that among participants in the 16–24-year age group who did not intend to consent to be vaccinated against COVID-19,' 12% (12/98) rated the seriousness of being infected by COVID-19 as a 1 (not at all serious). In the 25–34 age group more than 25% (n = 15/61) rated the seriousness of being infected by COVID-19 as a 1 (not at all serious).

Ordinal regression modelling showed that those who identified their ethnicity as BAME rated COVID-19 as more serious, compared to those who identified as White (OR 2.41 [95%CI: 1.12-5.17]). Male participants considered COVID-19 less serious than females (OR 0.34 [95%CI: 0.23–0.49]). The senior NCOs and junior officers viewed COVID-19 as less serious than junior ranks (OR 0.57 [95% CI: 0.39–0.85] and 0.53 [0.38–0.75], respectively). Similarly, those who were in logistics or "Other" branch considered COVID-19 more serious than those in the warfare branch. Responders with a maximum educational attainment of GCSEs or equivalent considered COVID-19 more serious, when compared to those with a bachelor's degree or higher (OR 1.72 [95%CI: 1.23–2.41]) (Table 2).

4. Discussion

The CRAB study is the first knowledge, attitudes and practise survey regarding COVID-19 in a UK military population, and the first to survey a whole military department, with other surveys only assessing small sub-groups of a service (23–25). Knowledge of COVID-19 transmission and symptoms was high across those who were surveyed, although after 15 months of the pandemic, the seriousness of the disease was

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TABLE 2 Association between COVID-19 severity score and vaccine hesitancy by demographics.

		No. of respondents (*n*)	Odds ratio	95% CI
Age group	16–24	565	1	NA
	25–34	489	0.76	0.58–1.01
	35–44	565	0.91	0.63–1.33
	45+	461	0.78	0.32–1.94
Biological sex	Female	359	1	NA
	Male	**1,721**	**0.34**	**0.23–0.49**
Ethnicity	White	1,978	1	NA
	BAME	**89**	**2.41**	**1.12–5.17**
	Preferred not to say	13	0.38	0.06–2.55
Rank	R1–OR4 (Junior rank)	877	1	NA
	R6–OR9 (NCO)	**541**	**0.57**	**0.39–0.85**
	OF1–OF3	**481**	**0.53**	**0.38–0.75**
	OF4+	181	0.59	0.13–2.58
Role/Branch	Warfare	536	1	NA
	Royal Marines	188	0.6	0.32–1.11
	Logistics	**242**	**2.41**	**1.54–3.78**
	Medical	237	1.56	0.64–3.84
	Engineer	667	0.98	0.72–1.35
	Air Crew	72	1.11	0.57–2.15
	Other	**137**	**2.29**	**1.36–3.86**
Education	Bachelor's degree or above	638	1	NA
	A/AS level (or equivalent)	673	1.06	0.76–1.48
	GCSEs—any grade (or equivalent)	**769**	**1.72**	**1.23–2.41**

Summary of ordinal logistic regression model investigating the association between COVID-19 severity score and vaccine hesitancy by demographics. The demographic and vaccine hesitancy status are categorical predictors with the COVID-19 seriousness the ordinal outcome. BAME, black and minority ethnic group; OR, other rank; OF, officer.
The bold values indicated to illustrate significant values to a reader quickly reading the article.

considered comparable to influenza. Isolation of positive cases and frequent cleaning were the two NPIs thought to be the most likely to prevent COVID-19, with protection of family and colleagues the two primary factors for respondents to adhere to NPIs. As vaccination numbers increased, COVID-19 was judged to be less serious in those vaccinated and a strong factor for non-adherence to NPIs. Those identified as vaccine hesitant appear comparable to rates among the UK civilian population, despite being a military population at increased risk due to exposure in constrained populations onboard military vessels (19).

The Royal Navy predominantly comprises of white Caucasian males, and the CRAB study is one of the largest surveys of this demographic but also adds valuable data to previous surveys and questionnaires targeting female, BAME and immunosuppressed populations (26–28). The 5C vaccination intention model is a useful tool to assess attitudes and behaviours to vaccines (20). In this study there was a high "confidence" in the vaccines (19). The perception that COVID-19 mostly affects older populations may engender "complacency" and therefore may contribute to vaccine hesitancy in this population (29). "Collective responsibility" may be a factor in increasing vaccine uptake in military populations. While not explicitly investigated in this study, previous studies have shown it to be a strong predictor of why individuals would adhere to COVID-19 NPIs (30). The Royal Navy did not place any barriers preventing individuals from being vaccinated, similar to

their civilian counterparts in the national vaccination rollout programme, therefore "constraints" is unlikely to be a significant reason for vaccine hesitancy. The request for more information regarding the vaccines appears to be comparable to other groups, although the trust with government and internal medical sources appears higher than previously observed (19).

Female sex, BAME ethnicity, being part of the logistics or other branch of the RN or having a maximal educational attainment of GCSEs or equivalent were associated with a higher COVID-19 seriousness score. Whilst age was not significant in determining COVID-19 seriousness, it is likely the junior ranks are younger, reflecting that age may have an impact. This study identified those who were older considered COVID-19 to be less serious. This is in contrast to data which suggests that older age is associated with higher compliance with preventative behaviours (11).

There were several limitations to this study. The study was only available for 14 days in the main phase; therefore, the response rate was low at 6.2% and below the intended response rate of 20–25%. The study window was 14 days, due to the haste of the UK vaccination rollout. If there was more time, and due to the low response rate, a stratification sampling method would have been the next step. The census sampling method was employed to take a rapid and easier "snapshot" of the organisation. As such, our findings may not reflect the wider RN population and therefore not generalisable for the whole organisation, although there were 2,000 responses. The data produced in the pilot phase was scrutinised by the study team for major discrepancies, although formal statistical testing of survey reliability and validity were not conducted, however it was based on a previously validated questionnaire. With a small sample size, the study is at risk of responder bias, although some mitigation measures were undertaken including the use of short concise questions, use of non-leading questions, use of interval questions and a short survey completion time. The largest cohort in this study were educated to degree level or higher. Higher educational attainment appeared to be associated with decreased compliance with preventative measures (31). While several vaccine hesitant individuals were identified, further information based on the 5C model was not collected, especially around confidence (vaccine safety and efficacy concerns) and collective responsibility, which is presumed to be high in a military population (20).

Whilst noting the limitations above, this study had a large number of responses, which was the highest in a military population (23–25). The study was also conducted at pace, when considering the rapid UK vaccination programme roll out and the loosening of COVID-19 restrictions as a result in decreasing numbers of infections and vaccination uptake (10). This study also further confirmed the literature that female sex and BAME ethnicity were associated with increased COVID-19 seriousness score (13, 14). The study also adds to the literature, by having one of the largest cohorts of young white Caucasian males sampled, with regards to their knowledge and attitudes towards COVID-19 preventative measures and vaccine uptake.

We consider there are two main benefits of this study. Firstly, it provided workforce-specific information, informing key RN policy makers and facilitating targeted information and educational campaigns for particular groups. Secondly, it shows that minor modifications to a validated knowledge and attitudes questionnaire can be quickly deployed and rapidly validated for other infectious diseases, increasing its potential future utility.

Data availability statement

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

Ethics statement

This study involving human participants were reviewed and approved by Ministry of Defence Research Ethics Committee. The patients/participants provided their written informed consent to participate in this study.

Author contributions

SW, RC, AL, PM, MT, TF, and MO'S all contributed to the study design and manuscript preparation. SW, RC, AL, and PM contributed to the data collection. SW, RC, and JB contributed to the data analysis. JB contributed to the statistical analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2022.1101817/full#supplementary-material

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Survey on public awareness, attitudes and self-protective behavior adoption in different periods of COVID-19

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Introduction: The outbreak and spread of the pandemics have been an issue of critical concern globally, posing a significant threat to the health sector globally. This study aimed to examine the basic knowledge and attitudes toward the recommended protective measures at different times, respond to the COVID-19 pandemic, and provide recommendations for developing targeted strategies and measures for preventing and controlling public health emergencies.

Methods: The study used self-filled questionnaires to examine the public's knowledge, attitudes, and practices on COVID-19 at two different period, from 20 to 31 March 2020 (the beginning period) and 22–27 April 2022 (the regular epidemic prevention and control period). Descriptive and quantitative analyses were used for statistical analysis.

Results and discussion: The survey collected 2375 valid questionnaires. A comparison of the two periods reveals that as the epidemic continued over a long period, the level of knowledge, attitudes toward preventive measures, risk perceptions, and adoption behavior of the respondents at the beginning of the epidemic were significantly higher than during the regular epidemic prevention and control period. With the upsurge in the spread of the epidemic, the public needs a multi-channel, targeted, and all-round guidance and information on prevention and control of the COVID-19, and internalizes knowledge into individual's behavior of actively responding to diseases.When the epidemic lasts for a long time, the relevant agencies should strengthen their monitoring role to promote public compliance with the recommended measures.

KEYWORDS

COVID-19, KAP, PADM, behavior adoption, different periods

Introduction

Public Health Emergencies are a common threat to human survival. In recent years, public health emergencies have frequently occurred globally with an increasingly expanding scope of influence (1, 2). In early 2020, the COVID-19 virus outbreak poses a severe threat to human life and health due to its rapid, widespread and highly contagious nature. It has posed an unprecedented challenge to the global public health system and government governance capacity (3). COVID-19 is the most rapidly spreading, widely infected and difficult to prevent and control major global public health event that has occurred in China.

The alarming incidence of COVID-19 and the resulting mass casualties have severely strained limited healthcare resources. Increasingly advanced technologies are being used to prevent the disease, such as early diagnosis and accurate classification of COVID-19 patients using x-ray images and voice signal processing techniques, the use of large amounts of data to track down people in close contact with infected individuals rapidly, and so on (4, 5).

At the same time, countries have put in place strict measures to prevent and control epidemics. For example, China "closed" high-risk cities at the epidemic's beginning (e.g., Wuhan residents were not allowed to leave the city from 23 January 2020). During the regular epidemic prevention and control period, the Chinese government requires the tracking and isolation of people from high-risk areas in the epidemic, the testing of body temperature when entering public places, the mandatory wearing of masks and the reduction of gatherings. In the United States, "workplace quarantine, temperature testing, and virus testing" and in some states, "14-day home orders" and "no gatherings of more than 10 people" were implemented. The public's active participation and compliance with the relevant systems and regulations are crucial to the prevention and control of the epidemic. However, there are many negative and non-compliant behaviors in the epidemic prevention and control system.

Unfortunately, there are still many people who do not follow these preventive recommendations. On 13 January, 2020, a man in Bengbu concealed a history of close contact with his relatives in Wuhan, leading to the emergency quarantine of 27 health care workers and 61 hospital patients (6). 21 July 2021, a woman in Yangzhou concealed a trip to Nanjing and frequently moved in crowded places, leading to the outbreak's spread in Yangzhou (7). These negative behaviors all reflect the non-compliance characteristics of the public toward the epidemic prevention and control measures, leading to the spread of the epidemic and posing a significant threat to the lives and health of the general public (8). At the same time, with the mutation of COVID-19, especially the emergence of the new Omicron, the current COVID-19 outbreak in China is still frequently occurring in different regions and spreading widely. Therefore, it is of great practical importance to discuss how to promote public compliance in the context of epidemic prevention and control. Although humans have defeated many past pandemics, future pandemics are unpredictable and inevitable. Hence, it is highly significant to develop public health solutions for pandemic prevention and control.

Most previous research on public health emergencies has focused on the epidemic's peak. However, as the epidemic situation changes, the public's focus varies during each period, leading to different compliance behaviors. There is a lack of research on public adoption of preventive measures at the regular epidemic prevention and control period. It is important to understand the behavior of the public during routine outbreak prevention and control when the epidemic lasts for a longer time. At the same time, comparative analyses for different periods of the same public health emergency are mostly conducted using retrospective surveys, and respondents may suffer from memory bias. Therefore, a questionnaire was creatively designed for this study to be administered during the peak and normal periods of the outbreak, effectively reducing the memory bias of the interviewees.

In the present study, we aimed to describe the dynamics of public awareness, attitudes, and adoption of self-protective behaviors among the Chinese population during the COVID-19 outbreak and during the regular epidemic prevention and control period, and to explore the reasons affecting adoption behaviors at different times. Findings from the study are expected to provide essential policy recommendations to the Public health department to help in decision-making, especially those related to epidemic prevention and disease control.

The Knowledge, Attitude, Practice model (KAP) and the Protective Action Decision Model (PADM) are frameworks for understanding public compliance with prevention recommendations to reduce the spread of epidemics (9, 10). The Knowledge, Attitude, Practice model is one of the models aimed at changing human health-related behavior. It is a behavior intervention theory, dividing the change in human behavior into three continuous processes of acquiring knowledge, conceptualizing ideas and forming responses.

Knowledge is the basis of action. The paradigm of disease prevention and health promotion depends mainly on understanding health behavior (11). When the public thinks that the disease will seriously affect health, they will choose to implement preventive and protective measures (12, 13). The lack of relevant knowledge was a significant reason for the epidemic rampage (14, 15). This idea guides the development of the hypothesis of this study, as follows:

H1: The degree of relevant knowledge is positively correlated with the intention of adoption.

Attitude change is the key to behavior adoption, and attitude is the driving force for behavioral change. Only when people form corresponding beliefs is when they can adopt a positive attitude to change their behavior. The more correct attitudes are, the higher the coordination of public actions (16).

From this we can hypothesize that:

H2: Attitude is positively related to the intention of adoption.

In the context of a rapidly developing media industry, rumors often emerge during diseases. The efficiency of information dissemination has a lasting impact on the prevention and control of an epidemic. Understanding the sources of public information about infectious diseases and the media channels they prefer to obtain information can provide the government with valuable information. Inaccurate health information can mislead the public and hinder the implementation of more effective measures (17). From this, we can hypothesize that:

H3: The information resolution ability is positively related to the adoption intention.

The Protective Action Decision Model (PADM) combines individuals' social environment, relevant information obtained, and the relevant personal risk experience. PADM contains three kinds of perception: risk perception, protective action perception, and stakeholder perception. It provides suggestions for disaster reduction by investigating the public's perception of these three aspects (18).

Empirically, an individual's subjective assessment of risk has been described as "risk perception" which describes the degree of the expected impact of a person exposed to potential risk. Specifically, the experiences of family members and friends around us in disasters are also included in personal risk experiences and information obtained from government authorities or media can improve risk perception (19). Risk perception forms the fundamental determinant of people's prevention of life-threatening events (20, 21). The lack of relevant information has caused the public misinformation on the viral disease currently experienced. Existing research shows that people who have a higher awareness of risk tend to have stronger willingness to adopt protective actions (22, 23). It can therefore be assumed that:

H4: Risk perception is positively related to the adopted intention.

There are two fundamental attributes of protective action perception, namely hazard-related attributes and resource-related attributes (24). Hazard-related attributes reflect the relationship between risk and protective behavior and reflect an individual's perception of the ability of the recommended preventive and protective measures to reduce risk. When people have a higher level of perception of hazard-related attributes, they tend to be more confident on the possibility of taking protective actions to reduce risks, and the actual adoption of behaviors will increase (25, 26).

Unlike the hazard-related attributes that emphasize the protective action on the risk, resource-related attributes measure the cost of adopting protective actions, including time, money, and the degree of cooperation required, and reflect the relationship between the resources spent and the protective actions. During the outbreak of infectious diseases, individuals will encounter obstacles such as forgetting to wash their hands, insufficiency of space to maintain social distancing, bearing the risk of vaccine side effects among others. When people perceive a higher level of resource demand, they will reduce their confidence in risk adjustment. The perceived high level of resource demand often leads to a low level of prevention behavior adoption. From this we can hypothesize that:

H5: The perception of hazard-related attributes is positively correlated to adopt preventive measures.
H6: Resource-related attribute perception is inversely related to the intention to adopt preventive measures.

Stakeholder perception is an individual's view of stakeholders' expertise, credibility, and protection responsibilities. People's distrust of the government and experts exacerbated existing concerns on preventive measures' effectiveness (27–29). Lack of trust in the governmental institutions and experts may overestimate the development of the epidemic, thereby being too nervous and causing panic (8, 27, 30). Strengthening the communication between the government and the public is conducive to enhancing public trust in the government (31), ensuring the public's correct understanding of the epidemic (32). It can therefore be assumed that:

H7: The public's perception of stakeholders is positively correlated with the adopted intentions.

Knowledge is the basis of action. Attitude change is the key to behavior adoption, and attitude is the driving force for behavioral change. Risk perception, protective action perception, and stakeholder perception are correlated with the adopted intentions. Based on the previous literature review and hypothesis proposal, the proposed operational mode is depicted in Figure 1.

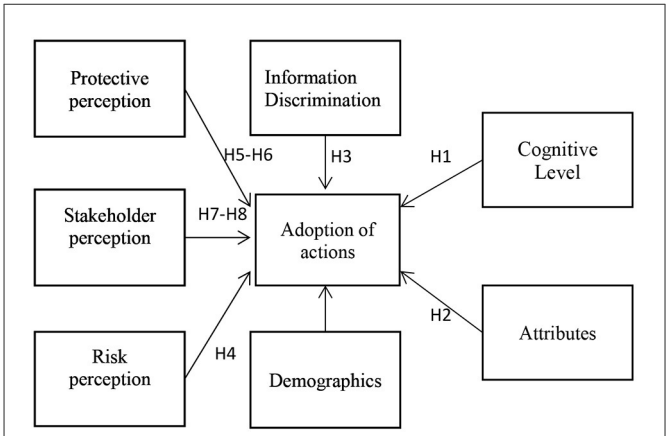

FIGURE 1
Framework diagram.

Methodology and data

Research instrument

We chose to distribute the questionnaires through an online platform to collect the data. The first cross-sectional survey on the status of the COVID-19 in China was conducted from 10 to 20 March 2020 for the "beginning period." The second cross-sectional survey, entitled "regular epidemic prevention and control period," was conducted from 22 to 27 April 2022. Although it was not possible to conduct a national community-based sample during that time, the data was collected electronically using Wenjuanxing.

Before the survey, participants were informed of the purpose of the study, assured of personal information confidentiality, and informed of their right to participate voluntarily. Participants were deemed to have given informed consent by beginning to complete the questionnaire after carefully reading the instructions section. This study resulted in a valid sample of 2,315 questionnaires from 30 provinces, municipalities and autonomous regions in China, excluding Tibet, Taiwan, Hong Kong and Macao, by removing those questionnaires that took <4 min to answer and those with 20 consecutive identical answers.

Measurement of key variables

The questionnaire consists of four parts. The first part deals with collecting general demographic data, such as gender, age, education and location. The second part presents the general knowledge of COVID-19. Five items were designed for the transmission route of COVID-19, susceptible groups, symptoms of infection, preventive measures and days of isolation. Participants who selected the three correct options were considered aware of transmission routes. The four options for susceptible populations were: generally susceptible, young people are not susceptible, people who smoke and drink regularly are not susceptible, and people who have exposure to the virus are susceptible. The options for symptoms of infection are "fever, dry cough"; "nasal congestion, cough"; "weakness, shortness of breath," "diarrhea." The researchers hypothesized that if participants selected "fever, dry cough," "weakness, shortness of breath," and "diarrhea," then they had a high awareness of the clinical features. Four options of protection were included, namely "cloth mask," "activated charcoal mask," "medical surgical mask," and "N95 protective mask." The researchers hypothesized that participants would have a higher awareness of protective measures if they chose the "medical-surgical mask" and "N95 protective mask". Four options were set for the duration of isolation, and those who chose 14 days were considered to understand better.

The third section includes adopting behaviors to prevent COVID-19, including keeping social distance, reducing travel, actively taking body temperature and wearing a mask. The potential possibility ranges from utterly impossible to affirmative realization,

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respectively 1 to 5 points. When each preventive measure's score is less than or equal to 3 points, it is regarded as bad behavior.

The fourth section includes respondents' judgments on information screening for COVID-19, attitudes toward preventive behaviors and stakeholder perceptions. The attitudes toward preventive measures in the study included whether they support the preventive measures, whether the preventive measures can effectively reduce exposure to infection and whether a citizen takes the precautionary measures. Express the respondents' views by measuring preventive measures' hazard-related attributes and resource-related attributes. The stakeholders' views were measured from their understanding of the COVID-19 pandemic and their responsibilities. The risk perception focused on the respondents' knowledge of the disease rate and mortality in terms of risk perception. They were all measured using Likert's 5-point scale Where "1" in the range represented utterly disagree, "3" generally was used to show the respondent neither agreed nor disagreed, whereas "5" represented utterly agree, and the average value is used as the measurement (See Table 1).

TABLE 1 Measurement of key variables.

Variable	Question
Intention to comply with recommended protective actions 1 = not at all likely 5 = almost certain	How likely is it that you would maintain good hygiene and timely disinfection?
	How likely is it that you would reduce going out?
	How likely is it that you would actively follow changes in your body temperature?
	How likely is it that you would wear masks?
Risk perception 1 = not at all likely 5 = almost certain	How likely do you think you are to get COVID-19 if you go out with a mask?
	How contagious do you think the COVID-19 is?
	How likely do you think you are to get COVID-19 if you receive a courier from a region with a severe outbreak?
	How likely do you think it is that you will die from getting COVID-19?
Attributes of recommended protective actions 1 = utterly disagree 5 = utterly agree	You support compliance with the recommended measures.
	Complying with recommended actions can protect your health.
	It is a citizen's duty to take preventive measures.
Stakeholder perception 1 = not at all likely 5 = to a very great extent	To what extent would you think that local community doctors/local city or state hospital doctors/local health department personnel/provincial or national public health department personnel/local government elected officials are knowledgeable about the COVID-19 virus?
	To what extent would you think local community doctors/local city or state hospital doctors/local health department personnel/provincial or national public health department personnel/local government elected officials are responsible for protecting you from the COVID-19 virus?
Information Discrimination 1 = utterly disagree 5 = utterly agree	For unconfirmed articles and information about the COVID-19 on the internet will not affect your normal life
	You think you know a lot about COVID-19
	You can effectively distinguish between rumors
Dangerous attributes 1 = utterly disagree 5 = utterly agree	Adherence to recommended measures can be effective in protecting health
	Complying with the recommended protective actions would also be useful for purposes other than avoiding COVID-19
Resource attributes 1 = utterly disagree 5 = utterly agree	Complying with the recommended protective action would cost a lot of money
	Complying with the recommended protective action would require a lot of effort or time
	Complying with the recommended protective action would require a lot of cooperation from others

Empirical method

While such descriptive analysis is based on a simple tabulation, it requires multivariate regressions to identify the multiple factors that can jointly determine the public's preventive measures decisions. As the public has five levels of willingness to accept behavior, which are ordered discrete variables, given the nature of the variables and the content of the study, this paper uses a logistic regression model to estimate the probability that a person is likely to adopt. The logistic regression model estimated the probability that a person might adopt, as a function of all factors that could potentially affect the public's decision to adoption; specifically, we will have:

$$\ln \frac{p}{1-p} = \partial + \sum_{i=1}^{n} \beta_i x_i + \varepsilon$$

P is the probability of person to adopt protective behavior, Xi are the independent variables that are expected to influence P. Y is the number of adoption protective behavior.

Results

Data analysis

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Sample profile

This summary of responses was obtained from those who participated in the survey during the beginning period (10–20 March 2020) and the regular epidemic prevention and control period (22–27 April 2022). Total responses were a combination of both. The survey collected 2,375 valid questionnaires. Among the 2,375 respondents, women and men accounted for 42.36 and 57.64%, respectively. In terms of education level, 77.68% of the respondents graduated from college/university, which showed that most of the respondents were educated and had a relatively clear understanding of the judgment of related items. In terms of monthly income, 31.71% of respondents had their annual household income ranging

between ¥ 90,000–199,999. In terms of living location, only 6.57% of interviewees resided in high-risk areas while 93.43% lived in low-risk areas. Furthermore, 55.49% of the respondents lived in the cities and 97.47% of interviewees didn't have contact with confirmed patients. The specific situation is provided in Table 2.

Respondent's overall knowledge level

The research data revealed that the majority of the participants had a high level of knowledge of preventive measures and days of isolation for novel coronary pneumonia, with 73.14 and 97.56% of respondents answering correctly. The lowest correct rate was for symptoms of infection, with only 10.15% of respondents answering correctly.

It can be seen that most residents maintained high levels of prevention, and had the relevant knowledge, especially on the protection and prevention measures, strictly related to life. Nevertheless, they lacked knowledge on more professional approaches to managing the virus, such as disease transmission and symptoms.

The survey time showed a 0.01 level of significance for the overall knowledge level, except for the knowledge of quarantine days. The respondent's level of knowledge at the beginning of the epidemic was significantly higher than during the regular period of the epidemic. The result shows that most residents are more concerned and knowledgeable about the epidemic at the beginning and that prevention and control education is better at the beginning of the epidemic. The specific situation is provided in Table 3.

Respondent's attitude toward preventive measures

According to the survey data, the respondents expressed support for the preventive measures to combat the spread of the COVID-19 pandemic (Table 4). 14.06% of the respondents supported the preventive measures, while 82.19% strongly supported the preventive measures. In terms of the effectiveness of preventive measures, 51.83% of the respondents strongly agreed that the precautionary measures could effectively prevent infection. Furthermore, a vast majority of the interviewees strongly agreed that citizens were obliged to take preventive measures during the epidemic, accounting for 72.67% of the total sample.

Comparing public attitudes between the two periods shows that public attitudes toward preventive measures were better at the beginning of the epidemic than during the regular epidemic prevention and control period. Although most of the public believed that preventive measures were needed and had some confidence in their effectiveness, public attitudes toward preventive measures tended to decline with the recurrence of the epidemic.

Respondent's perception toward risk

Table 5 shows the public generally believes that COVID-19 is highly contagious and has a high mortality rate. 64.93% of respondents thought COVID-19 was very infectious; 33.05% of respondents believed the death rate of COVID-19 were relatively high; It can be seen that most respondents have some anxiety and fear about COVID-19. However, 52.04% of respondents believed that taking protective measures (such as wearing masks) is somewhat likely to catch COVID-19. It can be found that the public has some confidence in the recommended preventive measures.

Comparing the public's risk perceptions between the two periods shows that the public's fear of the epidemic decreases and their fear of the disease diminishes as time passes. More people view the epidemic with a typical attitude.

Respondents' adoption of preventive actions

From the survey data, the survey respondents generally adopted a higher degree of preventive measures for the COVID-19 pandemic, which is related to the public knowledge on the preventive measures mentioned above and the supporting attitude toward the preventive measures (Table 6). Compared with other preventive measures, the number of respondents who chose to wear masks' frequency was higher. This situation is related to the need to wear a mask in public places during the epidemic.

The proportion of people wearing masks is significantly higher during regular epidemic prevention and control period. This is because the production of protective equipment such as masks reaches the demand during this period, there is no shortage of supply, and the public has access to the appropriate equipment.

Test the hypothesized paths

Table 7 shows the results of the logit model. First, it can be seen from the first column that the research subjects have a high cognition of the COVID-19 virus and that, positive attitude is among the most critical factors influencing the adoption of personal protective behavior. These data confirm that the influencing factors; H1 and H2 are established, that is: interviewees who have a higher level of awareness of the COVID-19 virus and a positive attitude toward preventive measures are more inclined to adopt preventive behavior. The level of public knowledge is one of the crucial factors that affect behavior. When the public has a higher awareness of the disease, adopting prevention behavior will be more likely. The correctness and timeliness of its preventive behavior will be higher. In terms of attitude, when the public takes a positive attitude toward preventive measures, it means that they are more confident on the possibility of taking protective actions to reduce risks, and the actual adoption of activities will increase. However, the effect on the cognitive level was not significant during the regular epidemic prevention and control period, which may be related to the fact that as time progressed and the epidemic eased, people were less concerned about COVID-19 itself.

Secondly, the third-row results support H3, which hypothesized that; information resolution ability would significantly positively impact the willingness to prevent adoption. The regression coefficient value of the information resolution ability was 0.714 at a significance level of 0.01. The public with a stronger ability to distinguish information will have a better understanding of preventive behaviors and the higher the accuracy and timeliness of taking preventive practices, especially during the beginning period.

It can be seen from the results in Table 7 that the level of risk perception is positively correlated with the probability of the public adopting preventive behaviors. So H4 is established, and the public members with a higher awareness level of risk tend to have a stronger willingness to adopt protective actions. Their fear of the disease

TABLE 2 Descriptive statistics.

Variable	Descriptive	Beginning period, *n* (%)	Regular epidemic prevention and control period, *n* (%)	Total, *n* (%)
Gender	Female	760 (59.33)	609 (55.67)	1,369 (57.64)
	Male	521 (40.67)	485 (44.33)	1,006 (42.36)
Education	Junior high school	93 (7.26)	6 (0.55)	99 (4.17)
	High school	193 (15.07)	67 (6.12)	260 (10.95)
	College/university	890 (69.48)	955 (87.29)	1,845 (77.68)
	Master's degree and above	105 (8.20)	66 (6.03)	171 (7.20)
Annual household income	Below ¥30,000	159 (12.41)	50 (4.57)	209 (8.80)
	¥ 30,000–59,999	235 (18.35)	118 (10.79)	353 (14.86)
	¥ 60,000–89,999	246 (19.20)	218 (19.93)	464 (19.54)
	¥ 90,000–1,99,999	346 (27.01)	407 (37.20)	753 (31.71)
	Over ¥ 1,20,000	295 (23.03)	301 (27.51)	596 (25.09)
Regional risk	High-risk areas	86 (6.71)	70 (6.40)	156 (6.57)
	Low-risk areas	1,195 (93.29)	1,024 (93.60)	2,219 (93.43)
Living location	City	731 (57.06)	587 (53.66)	1,318 (55.49)
	Town	258 (20.14)	412 (37.66)	670 (28.21)
	Rural area	292 (22.79)	95 (8.68)	387 (16.29)
Experience	Is a confirmed patient	3 (0.23)	7 (0.64)	10 (0.42)
	Contact with confirmed patients	17 (1.33)	33 (3.02)	50 (2.11)
	No contact with confirmed patients	1,261 (98.44)	1,054 (96.34)	2,315 (97.47)

TABLE 3 The public's knowledge about COVID-19.

		Beginning period, *n* (%)	Regular epidemic prevention and control period, *n* (%)	Total	χ^2	*p*
Disease transmission	Incorrect	998 (77.91)	988 (90.31)	1,986 (83.62)	66.275	0.000***
	Correct	283 (22.09)	106 (9.69)	389 (16.38)		
	Total	1,281	1,094	2,375		
People easily infected	Incorrect	686 (53.55)	641 (58.59)	1,327 (55.87)	6.08	0.014**
	Correct	595 (46.45)	453 (41.41)	1,048 (44.13)		
	Total	1,281	1,094	2,375		
Infection symptoms	Incorrect	1,086 (84.78)	1,048 (95.80)	2,134 (89.85)	78.56	0.000***
	Correct	195 (15.22)	46 (4.20)	241 (10.15)		
	Total	1,281	1,094	2,375		
Protective measures	Incorrect	295 (23.03)	343 (31.35)	638 (26.86)	20.81	0.000***
	Correct	986 (76.97)	751 (68.65)	1,737 (73.14)		
	Total	1,281	1,094	2,375		
Quarantine days	Incorrect	25 (1.95)	33 (3.02)	58 (2.44)	2.808	0.094*
	Correct	1,256 (98.05)	1,061 (96.98)	2,317 (97.56)		
	Total	1,281	1,094	2,375		

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

diminishes as time passes. More people view the epidemic with a typical attitude. The positive effect of the level of risk perception on the probability of the public adopting preventive behavior during the regular epidemic prevention and control period is not significant, possibly because their fear of the disease diminishes as time passes. More people view the epidemic with a typical attitude.

Among the two attributes of protective behavior perception, the regression coefficient value of the hazard attribute was 0.381, and at a

TABLE 4 Public attitudes toward preventive measures.

		Beginning period, n (%)	Regular epidemic prevention and control period, n (%)	Total	χ^2	*p*
Support for preventive measures	Strongly Disagree	1 (0.08)	3 (0.27)	4 (0.17)	34.572	0.000***
	Disagree	4 (0.31)	8 (0.73)	12 (0.51)		
	Neutral	22 (1.72)	51 (4.66)	73 (3.07)		
	Agree	152 (11.87)	182 (16.64)	334 (14.06)		
	Strongly agree	1,102 (86.03)	850 (77.70)	1,952 (82.19)		
	Total	1,281	1,094	2,375		
Preventive measures can effectively avoid infection	Strongly Disagree	2 (0.16)	2 (0.18)	4 (0.17)	28.882	0.000***
	Disagree	6 (0.47)	15 (1.37)	21 (0.88)		
	Neutral	61 (4.76)	74 (6.76)	135 (5.68)		
	Agree	488 (38.10)	496 (45.34)	984 (41.43)		
	Strongly agree	724 (56.52)	507 (46.34)	1,231 (51.83)		
	Total	1,281	1,094	2,375		
It is a citizen's duty to take preventive measures	Strongly disagree	3 (0.23)	3 (0.27)	6 (0.25)	10.547	0.032**
	Disagree	4 (0.31)	11 (1.01)	15 (0.63)		
	Neutral	28 (2.19)	41 (3.75)	69 (2.91)		
	Agree	296 (23.11)	263 (24.04)	559 (23.54)		
	Strongly Agree	950 (74.16)	776 (70.93)	1,726 (72.67)		
	Total	1,281	1,094	2,375		

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

0.01 level of significance, showing that the hazard attribute will have a significant positive impact on the willingness to adopt preventive actions. The regression coefficient value of the resource attribute was −0.074. Still, it does not show significance, which means that the resource attribute does not affect the willingness to adopt preventive behaviors. In the early stage of the pandemic, there could have been resource insufficiencies. However, the Chinese government's strong execution force mobilized medical personnel and various protective resource production enterprises to increase production to ensure that most public can easily access the various protective equipment. Local governments have adopted various measures to combat the pandemic, resulting in weaker resource attributes.

In terms of stakeholder perception, stakeholder understanding will significantly impact the willingness to adopt preventive behaviors whereas stakeholder responsibility will not affect the desire to adopt during the beginning period.

At the same time, different demographic characteristics have different effects on the adoption of preventive measures. The education level and income level had a significant positive impact on the willingness to adopt preventive behaviors. Respondents with higher education levels tended to take preventive actions, and respondents with higher incomes are more capable of purchasing protective equipment to complete preventive practices. However, the effect of education level was not significant in times of regular epidemics, but rather the effect of exposure to confirmed patients was more pronounced.

Discussions and implications

This study is essential in understanding the factors that affect the public's acceptance of recommended preventive measures during the different periods. From the survey data, the survey respondents generally adopted a higher degree of preventive measures of COVID-19. The degree of understanding, attitudes to preventive measures, ability to confirm the authenticity and truthfulness of information, risk perception, stakeholder understanding of the pandemic situation, risk attributes, education level, and salary level will significantly impact the adoption of preventive measures. Furthermore, it is of great significance to the relevant departments in providing references for related disease prevention and intervention strategies. The level of knowledge, attitudes to preventive measures, risk perceptions, and adoption behavior of respondents at the beginning of the epidemic were significantly higher than during the normalization. Over time, public concern and fear of the epidemic declined, and more people viewed the epidemic as usual. It is, therefore, necessary to tailor epidemic preparedness measures to different periods.

There is a link between information and knowledge dissemination and behavioral compliance. During a pandemic, many people cannot realize the impact compliance with the appropriate recommended behaviors can have on outbreak prevention or stopping the spread of an epidemic because they do not have sufficient knowledge or the right information. More importantly, in the current age of information explosion, people are

TABLE 5 Public perception of risk.

		Beginning period, *n* (%)	Regular epidemic prevention and control period, n (%)	Total	χ^2	*p*
How likely do you think you are to get COVID-19 if you go out with a mask?	Not at all likely	183 (14.29)	69 (6.31)	252 (10.61)	100.497	0.000***
	Less likely	722 (56.36)	514 (46.98)	1,236 (52.04)		
	Likely	264 (20.61)	322 (29.43)	586 (24.67)		
	Very likely	69 (5.39)	134 (12.25)	203 (8.55)		
	Almost certain	43 (3.36)	55 (5.03)	98 (4.13)		
	Total	1,281	1,094	2,375		
How likely do you think you are to get COVID-19 if you receive a courier from a region with a severe outbreak?	Not at all likely	328 (25.60)	19 (1.74)	347 (14.61)	693.488	0.000***
	Less likely	620 (48.40)	254 (23.22)	874 (36.80)		
	Likely	257 (20.06)	394 (36.01)	651 (27.41)		
	Very likely	58 (4.53)	362 (33.09)	420 (17.68)		
	Almost certain	18 (1.41)	65 (5.94)	83 (3.49)		
	Total	1,281	1,094	2,375		
How likely do you think COVID-19 is to be contagious?	Not at all likely	2 (0.16)	3 (0.27)	5 (0.21)	12.865	0.012**
	Less likely	7 (0.55)	14 (1.28)	21 (0.88)		
	Likely	24 (1.87)	42 (3.84)	66 (2.78)		
	Very likely	410 (32.01)	331 (30.26)	741 (31.20)		
	Almost certain	838 (65.42)	704 (64.35)	1,542 (64.93)		
	Total	1,281	1,094	2,375		
How likely do you think it is that you will die from getting COVID-19?	Not at all likely	46 (3.59)	61 (5.58)	107 (4.51)	12.731	0.013**
	Less likely	303 (23.65)	252 (23.03)	555 (23.37)		
	Likely	365 (28.49)	353 (32.27)	718 (30.23)		
	Very likely	441 (34.43)	344 (31.44)	785 (33.05)		
	Almost certain	126 (9.84)	84 (7.68)	210 (8.84)		
	Total	1,281	1,094	2,375		

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

often misinformed by false news or misinformation. Decision-makers must ensure three key characteristics: information quality, timeliness, and trustworthiness to increase public acceptance of the proposed measures. The relevant authorities need to report the occurrence and progress of an event openly and transparently and follow up continuously after the event to enhance the level of information perception to stabilize the public's response to the event. Corresponding information dissemination methods should be formulated for different groups to improve information dissemination effectiveness. For example, for people who do not frequently use the Internet and other news media, traditional media's propaganda efforts, such as television, newspapers, and radio, can be strengthened. Relevant departments need to strengthen education's role to improve information discrimination ability for people with low educational background. The means of disseminating health knowledge should be diversified. For example, posters, folders, and cartoons can attract the public and arouse their attention and interest in health knowledge or stimulate public participation in health knowledge activities through knowledge competitions, science talks, and skills competitions.

Secondly, risk perception plays a crucial role in predicting behavioral intentions. When people realize a strong correlation between risk perception and intent to act, they tend to follow the provided recommendations. Therefore, strengthening the communication ability between the government and the public by updating the risk status in time will help the public take corresponding preventive measures and reduce infectious diseases.

Thirdly, Stakeholders' understanding of the pandemic situation has a significant positive impact on adopting preventive measures by the public. The government needs to make the information available more transparently and openly. To enhance public trust in the government, the health department leaders need to

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TABLE 6 Public adoption of preventive actions.

		Beginning period, *n* (%)	Regular epidemic prevention and control period, *n* (%)	Total	χ^2	*p*
Disinfect in time	Impossible	5 (0.39)	3 (0.27)	8 (0.34)	50.466	0.000***
	A bit possible	44 (3.43)	18 (1.65)	62 (2.61)		
	Possible	140 (10.93)	110 (10.05)	250 (10.53)		
	Very likely	497 (38.80)	576 (52.65)	1,073 (45.18)		
	For sure	595 (46.45)	387 (35.37)	982 (41.35)		
	Total	1,281	1,094	2,375		
Reduce going out	Impossible	19 (1.48)	19 (1.74)	38 (1.60)	69.84	0.000***
	A bit possible	56 (4.37)	63 (5.76)	119 (5.01)		
	Possible	116 (9.06)	149 (13.62)	265 (11.16)		
	Very likely	323 (25.21)	395 (36.11)	718 (30.23)		
	For sure	767 (59.88)	468 (42.78)	1,235 (52.00)		
	Total	1,281	1,094	2,375		
Wear masks	Impossible	5 (0.39)	4 (0.37)	9 (0.38)	275.034	0.000***
	A bit possible	41 (3.20)	13 (1.19)	54 (2.27)		
	Possible	194 (15.14)	63 (5.76)	257 (10.82)		
	Very likely	535 (41.76)	212 (19.38)	747 (31.45)		
	For sure	506 (39.50)	802 (73.31)	1,308 (55.07)		
	Total	1,281	1,094	2,375		
Daily body temperature	Impossible	11 (0.86)	6 (0.55)	17 (0.72)	59.573	0.000***
	A bit possible	58 (4.53)	58 (5.30)	116 (4.88)		
	Possible	222 (17.33)	200 (18.28)	422 (17.77)		
	Very likely	462 (36.07)	535 (48.90)	997 (41.98)		
	For sure	528 (41.22)	295 (26.97)	823 (34.65)		
	Total	1,281	1,094	2,375		

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

strengthen their professional qualities to avoid shortcomings that are difficult to deal with in public health emergencies. At the same time, attention should also be directed to grass-roots managers' supervisory role, strengthen residents' self-detection and prevention, and ensure that infected persons are put on isolation for treatment in time.

Fourthly, risk attributes have a significant positive impact on the adoption of preventive measures. Relevant departments need to conduct a more comprehensive and detailed interpretation, introducing disease-related risk factors and prevention and control methods to strengthen public confidence in recommending preventive measures.

Fifthly, the general public needs to enhance their awareness of self-protection, develop good hygiene habits, wash hands regularly, frequently ventilate, wear masks, and frequently disinfect, etc. It is also necessary to enhance personal protection by strengthening physical fitness and improving personal immunity, maintaining a healthy lifestyle, eating a healthy diet to provide adequate nutrition, exercising in moderation to improve body resistance, and regularly working to maintain a good night's sleep.

In addition, when an epidemic lasts for a long time, 'pandemic fatigue' may set in and make people less willing to follow recommended behaviors. The level of knowledge, attitudes to preventive measures, risk perceptions, and adoption behavior of respondents at the beginning of the epidemic were significantly higher than during the normalization. When the epidemic subsides, the authorities should take measures to prevent people from letting their vigilance down. Government agencies should strengthen their monitoring role in such cases to promote behavioral change. During the regular epidemic prevention and control period, more emphasis should be placed on promoting prevention and control knowledge through diverse methods such as integrating new and traditional media to strengthen public awareness of epidemic prevention and to guard against prevention burnout. The relevant authorities need to update information throughout the event cycle according to the different dynamics and levels of disruption. At the same time, government agencies should strengthen their oversight role to promote behavioral change while ensuring the supply of protective materials and simplifying the management of the epidemic prevention and control process to reduce the cost of prevention and control behaviors to reduce "pandemic fatigue".

TABLE 7 Logit model results.

	Total	Outbreak period	Regular epidemic prevention and control period
Cognitive level	0.093*	0.127**	0.058
	(0.048)	(0.063)	(0.077)
Attitude	0.702***	0.661***	0.775***
	(0.115)	(0.183)	(0.154)
Information discrimination	0.714***	0.972***	0.515***
	(0.072)	(0.111)	(0.097)
Risk perception	0.307***	0.401***	0.18
	(0.088)	(0.123)	(0.127)
Dangerous attributes	0.381***	0.396***	0.454***
	(0.092)	(0.152)	0.123
Resource attributes	−0.074	−0.037	−0.062
	(0.056)	(0.082)	(0.08)
Stakeholder understanding	0.639***	0.716***	0.555***
	(0.097)	(0.129)	(0.151)
Stakeholder responsibility	0.183**	0.075	0.327***
	(0.069)	(0.091)	(0.108)
Education level	0.270***	0.288***	−0.111
	(0.073)	(0.085)	(0.164)
Income	0.195***	0.177***	0.134**
	(0.035)	(0.047)	(0.059)
Regional risk	0.003	−0.041	0.193
	(0.041)	(0.049)	(0.101)
Living location	0.211	0.088	0.489*
	(0.207)	(0.386)	(0.256)
Experience	−0.142	−0.152	−0.135
	(0.167)	(0.229)	(0.252)
Likelihood ratio test	χ^2 (13) = 571.565, $p = 0.000$	χ^2 (13) = 328.451, $p = 0.000$	χ^2 (13) = 276.440, $p = 0.000$
N	2,375	1,281	1,094

***$p < 0.001$, **$p < 0.01$, *$p < 0.05$.

Conclusions

This study is essential in understanding the factors that affect the public's acceptance of recommended preventive measures during the different period. Furthermore, it is of great significance to the relevant departments in providing references for related disease prevention and intervention strategies. The level of knowledge, attitudes to preventive measures, risk perceptions and adoption behavior of respondents at the beginning of the epidemic were significantly higher than during the normalization of the epidemic. Over time, public concern and fear of the epidemic declined, and more people viewed the epidemic in a usual way. It is, therefore, necessary to tailor epidemic preparedness measures to different periods.

Using an online questionnaire for data collection means that respondents with only an internet connection are more likely to participate, which may lead to errors, such as a disproportionate number of well-educated people in this survey. Therefore, the findings may not be representative of the views of less-educated people. Also, the small sample size obtained for this survey in areas with severe outbreaks limits the derivation of conclusions. Subsequently, further research can be carried out by expanding the sample size and improving the sampling method.

The design of the COVID-19 cognitive level scale was based on the COVID-19 Prevention and Control Programme and the Public Protection Guidelines, which may need to be more comprehensive. While residents' behavior in complying with epidemic prevention policies and systems is studied from a holistic perspective, there may be differences in residents' psychological perceptions and actual behavior toward mandatory and non-mandatory requirements. Future studies can examine different types of epidemic prevention policies and measures separately or in comparison to enrich the findings on residents' adoption of epidemic prevention behavior.

Data availability statement

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

Author contributions

FF: conceptualization, methodology, and writing—review and editing. SC: formal analysis and writing—original draft preparation. XG and EK: writing—review and editing. All authors read and approved the final manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The necessity revealed by COVID-19 pandemic: Paradigm shift of Iran's healthcare system

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Background: COVID-19 pandemic has resulted in drastic changes around the world, revealing vulnerable aspects of healthcare systems. This study aimed to explore how Iranian healthcare system experienced the paradigm shift during the pandemic and determine the aspects that need improvement during the pandemic era.

Method: This qualitative study was conducted in 2021. A framework analysis approach was used to analyze the content of the 19 semi-structured interviews with the healthcare system experts from Shiraz University of Medical Sciences (SUMS). The interviews' audio files changed into transcript after each session and data was saturated at the 19 interview. To increase the trustworthiness of the study, Guba and Lincoln's criteria including credibility, transferability, dependability, and confirmability were used. Goldsmith's five-step framework analysis was used applying MAX QDA version 10 software.

Result: Eight main themes and 20 subthemes were explored. The main themes included "strengthening the electronic health infrastructure," "research for evidence-based decision making," "dedicated financing to the pandemic," "prevention of disruption in the effective provision of services and medicines," "enriching the authority of the Ministry of Health by focusing on interactions," "recruiting, managing and empowering health human resources with attention to financial and non-financial incentives," "reforming educational approaches in training students in medical universities," as well as "lessons learned from neglected aspects."

Conclusion: To be ready to respond to a possible future pandemic and for a paradigm shift, bold steps must be taken to make fundamental changes in various aspects of the healthcare system including e-health development, evidence-based decision making, dedicated budgets for pandemics, reinforcement of interactions at the national and international level, as well as sufficient attention to healthcare workers from all financial, non-financial and educational aspects.

KEYWORDS

COVID-19, pandemic, paradigm shift, challenges, health system, healthcare system

Introduction

COVID-19 was announced as a pandemic on March 11, 2020 and resulted in drastic changes around the world with significant negative outcomes on all aspects of the population's life (1, 2). The pandemic's effects could not only be mentioned from the health perspective but also could be considered from its significant impacts on all other environmental, social, educational, and

economic aspects of the communities (2, 3). Without a doubt, COVID-19 pandemic put the most pressure on healthcare systems, and this led to the revelation of less-than-optimal resilience of even high-performing healthcare systems (4). Such an unprecedented pressure almost put healthcare systems on the verge of collapse in many developing countries (5).

The possible imbalance between supply and demand factors intensifies the adversities and vulnerabilities of healthcare systems during any humanitarian crisis, and this has been acutely experienced during the COVID-19 pandemic, reflecting the vulnerability of healthcare systems in countries around the world. The pandemic apparently clarified that healthcare systems could be more vulnerable in the face of unequal demands (5). Some countries that were long thought to have the best or close to the best healthcare systems in the world seem to have realized after the outbreak of COVID-19 that they may have been wrong for a long time; because of this pandemic, the problems of their healthcare systems, including barriers to access, uncontrolled costs, unacceptable quality, and wide disparities, were clearly revealed (6). In fact, this pandemic imposed a serious pressure on the performance of the healthcare systems and as a result, many of these systems became profoundly unstable and lost their capacity of care due to a sudden and severe change or shock. At the same time, healthcare systems faced specific challenges, including disease burden and excessive mortality which led to delays in urgent non-COVID care (7).

Delays in routine healthcare during COVID-19 are a critical issue, not only because of the magnitude of delays that occurred during the pandemic, but also due to the sheer volume of delays in routine care. According to the evidence, colon and breast cancer screenings dropped by more than 80% and the healthcare delays negatively affected quality of life, morbidity, and mortality among the population (8). Another complication of this pandemic is the increase in the possibility of malnutrition due to quarantine and unemployment, which leads to the negation of the achievements of the national health and nutrition programs. But the more worrying aspect is the lack of proper safety nets (e.g., food safety) at least for the most vulnerable population (9).

Several factors led the healthcare systems toward this set of challenges and complications. On the one hand, fragility and unpreparedness of healthcare systems, lack of resources along with poor service delivery made the healthcare systems collapse during the pandemic (10). For example, in India, poor health infrastructure coupled with poor logistics led to severe oxygen shortages despite having excess oxygen capacity (5). Other evidence indicates the negative effects of the pandemic on healthcare services' delivery due to human resources' challenges. The main concerns in this field include the number, distribution, type, and performance of healthcare workers. It is quite clear that the optimal management of health human resources and the timely identification of related challenges in this field are the way for policymakers to better manage this pandemic (11).

Considering all the above, healthcare policymakers are seeking approaches to make the systems more resilient and flexible. Among them a four-stage life cycle of shocks is notifiable. According to this cycle, a healthcare system first tries to be prepared; identify onset and act rapidly. Then the impacts are managed to preserve healthcare system access and quality as well as dealing with legacy issues thereafter (7). Such approaches need an appropriate evidence-based decision-making mechanism based on strong research skills, the capacity to conduct accurate and rapid research, evidence evaluation, as well as structures for informed decision-making (12). Along with the set of solutions and approaches to increase the responsiveness of the healthcare systems, measuring, monitoring, and reporting performance can lead to a balanced responding mechanism to COVID-19 pandemic (13).

All in all, COVID-19 is not the first pandemic, and it will not be the last (14). Beyond defeating this pandemic, the big test that all countries will soon face is whether the lessons from this experience have shaped new shared goals after the crisis (6). Although this crisis revealed the need for a paradigm shift in public health policies (15), it has led to a paradigm shift to prepare for future crises (16).

Iranian healthcare system like other similar settings faced multiple difficulties during the pandemic. An ongoing challenge is coping with the pandemic condition along with the insufficient coordination between the internal and external sectors. This issue is mostly due to the lack of a proper crisis management plan. Among other challenges, one may mention transparency in information and building public trust. It seems the officials involved in this crisis have not adopted appropriate information policies and programs during this crisis. Sometimes the delay in providing statistics has led to increased society concerns and the creation of incorrect and false information. Also, in the past years, due to the treatment-oriented attitude of the Ministry of Health and the delay in the implementation of the family physician program, as well as insufficient attention to primary health care, the management of the COVID-19 pandemic has faced many problems (17, 18).

Considering the above, this research aimed to explore how Iranian healthcare system experienced the paradigm shift during the pandemic and determine the aspects that need improvement during the pandemic era. The present results could shed the light for Iranian health policymakers and those with similar settings to improve the performance, resilience, and responsiveness of the healthcare systems during the pandemics.

Methods

Study setting

This was a qualitative study conducted in 2021 applying a framework analysis approach. The study setting consisted of the experts affiliated with Shiraz University of Medical Sciences (SUMS). This is the largest and the most high-rank university in south of Iran and is considered as the referral system for many other universities all are affiliated with the Iranian Ministry of Health and Medical Education (MOHME). Considering the structure of Iranian healthcare system, MOHME is responsible for the population's health and policymaking at the national and local levels; all other medical centers and service providers, as well as research and educational centers, such as SUMS are supervised by MOHME.

Study participants

The study participants, including those experts with administrative and practical experience in primary health care,

TABLE 1 Participants categories.

Variables	Divisions	Frequency
Position	Health policy makers	7
	Deputy health officials	4
	Faculty member	4
	Executive directors of the health department	4
Gender	Male	16
	Female	3
Working experience	<10	5
	≥10	14

health policy and healthcare system were selected. For achieving more comprehensive opinions, those academic members who had related scientific experience, related research and executive experiments were also included.

To increase the variety and heterogeneity of the participants, a purposeful sampling was applied and followed by a snowball sampling method. The inclusion criteria for the purposeful sampling were having at least 3 years' experience in the areas of primary health care, health policy making and healthcare system or health executive management and leadership as well as willingness to participate. Following the snowball sampling and in accordance with the introduction of the initial purposeful participants, other individuals who could contribute and help develop the concepts were recognized. The study's withdrawal condition was unwillingness to participate.

According to the described protocol for data collection, at the first step, two participants were selected purposefully (Head of Health Policy Center and Vice President of Health at SUMS). Then, 17 participants were included by snowball sampling who were all considered as the key health policy makers and leaders in the management of COVID-19 pandemic at SUMS. All of them had sufficient experience and information and were willing to participate. At this level, after 19 semi-structured individual interviews the data was saturated, and no new concept was generated.

Demographic characteristics including education level, specialization, management experience, age, and marital status were registered for the interviewees. The characteristics of the participants in the research are given in Table 1.

Data collection

Semi-structured interviews were used to collect comprehensive insight from included experts by one of the researchers (MM) during December 2020 and January 2021.

To prepare the interview guide, a quick literature review was conducted as well as the opinion acquisition of selected experts. To ensure the meaningfulness and validity of the questions, two pilot interviews were conducted with the faculty members in the field of health policy who were not included as the main participants. The final interview guide included a warm-up question, and 12 main and sub-questions as well as probing questions.

The interview sessions were conducted with prior coordination with the participants at their favorite time and preferably in the workplace and face-to-face. At the beginning of the interview, general explanations about the study and its objectives, as well as the measures taken to keep their information confidential, were presented orally. Also, a written informed consent form was obtained from all the interviewees and the participants were assured that they could stop the interview process at any stage. With the permission of the interviewees, all the interview sessions were recorded and for more accuracy, their non-verbal gestures were noted. Each interview lasted at least 50 min and all interviews were conducted by one researcher (MM) and continued until reaching the saturation level. As soon as possible after the end of each interview, the audio recordings were transcribed verbatim. Since the interviews were in Farsi, the quotes were translated from the original by the study team.

Data analysis

To analyze the data, Goldsmith's five-step framework analysis method was used (19).

- In the first step, for the purpose of familiarization, the audio recordings from the interview sessions were transcribed verbatim, and to ensure the initial and targeted understanding of the data, the texts were reread several times. During this step, by immersing in the data and taking notes on key ideas, the researcher began to understand the main themes in the data, and this step continued until the researcher felt a reasonable initial understanding had been reached.
- In the second step, the analysis moved from the concrete descriptions of the themes in the data toward the identification of more abstract concepts, and with the aim of providing a framework or structure for interpretation, the repeated ideas in the familiarization step became groups consisting of similar ideas. In fact, the themes and concepts were categorized and arranged in such a way that it helped the researcher to focus on the study and interpret the findings in an organized manner.
- After a reasonable framework was identified, this framework was systematically applied to all study data. In this process, which is called indexing, units and parts of data that were related to a specific theme were identified.
- In the fourth step, which is called charting, the data were summarized and tabulated based on the thematic framework, to provide the possibility of a totality and systematic examination of the data.
- Finally, in the fifth step, the data were finally combined. The researcher tried to tell a compelling story about how the data was structured and patterned, and used mapping to describe key concepts, their nature, or scope, and to show connections between key concepts.

All the data analysis process was implemented by two of the researchers with no conflict of interest. Reflexivity of qualitative data analysis was also assured as the research team members have sufficient experience in this field and have published several qualitative articles in English.

Trustworthiness criteria of the qualitative study

To ensure the trustworthiness of the research data, the four criteria proposed by Lincoln and Guba, including credibility, transferability, dependability, and confirmability, were used.

To ensure the credibility of the study, the method of long-term participation and interaction between the researchers and the participants was used. To ensure the transferability, a thick description of the data was used. The research environment, the conditions of the participants and the interview method were clearly defined. Also, an in-depth description of the data, how to code and analyze movements and texts, was provided. And, to confirm the dependability of the research, the step-by-step repetition method was used to analyze and collect data. Finally, to ensure the confirmability of the research, cross-checking with other members of the research team was used, and expert check and peer check were applied for data accuracy.

Result

The findings from the analysis of the interviews led to the identification of 8 main themes and 20 sub-themes (Table 2).

Strengthening the electronic health infrastructure

Strengthening the electronic health infrastructure includes four sub-themes as follows: integrating the health information system, data accuracy, comprehensiveness data, data security The interviewees believed that the e-health infrastructure should be strengthened to generate evidence and provide services. One of the participants as a primary health care manager with more than 10 years of experience stated:

> "*...for example, we have a SIB system)* Integrated health system *(, on the other hand, we have several portals where information has to be recorded in several places, repetitive and sometimes unnecessary information, which makes it impossible to report correctly and on time, and the accuracy of the information was also a problem...*" [P5/ deputy health officials]

Another participant expert in health policies said:

> *"At all, the SIB)* Integrated health system *(cannot be considered as an electronic health file, the SIB system, which the information of the MOHME is leaked with the ID number, the most obvious characteristic of a system is that it has information security".*

The interviewees believed that the existence of a database facilitates the evidence-based decision-making process. One interviewee stated that:

> *"The most important thing in a pandemic is a decision based on evidence. Evidence means data and information, and according to the famous pyramid that we know, at the bottom of that data, next is information, knowledge, and then decision"*

One of the concerns raised in this study was improving health information systems so that they provide optimal information dashboards for policy makers, researchers, and managers. As an example, one of the participants with experience in health policy making stated:

> *"... important information should be available to managers for decision-making, and the prerequisite for that is the creation of a broad and integrated information system"* [P11/ health policy makers].

As a result of this research, one of the issues raised was the strengthening of digital health infrastructure. Despite the seriousness of this issue around the world, it appears that digital health structures in Iran are still incomplete and underdeveloped. one of the participants with experience in health policy making stated:

> *"Another discussion is that the future of health systems is going toward digitalization. This is a very important discussion. Meetings are held in European countries, and they are looking to strengthen telehealth and compensate part of the weakness of their system in this way, and they are preparing... Now you come and design a system for this purpose, did you work in a forward-looking way? No. Because the systems are tools and the infrastructure of manpower, training and equipment must be provided first..."*

The participants believed that information systems should be sensitive to statistics and give automatic warnings about risks. In this regard, one of them said:

> *"Creating a smart information network for timely diagnosis of epidemics and diseases in the country for the post-pandemic era can be very helpful"* [P14/ health policy maker].

Research for evidence-based decision making

Research for evidence-based decision making includes two sub-themes as follows: Applied research in health and prevention, preparing a national road map for research. A participant stated that:

> *"This restricted access to data must be resolved. When the data is collected, it must be thought of for its dissemination, that is, it must be leveled, and each part can have specific access to the data. MOHME should have one level of access while the researchers need another level of access and similarly for the public, otherwise we may make wrong decisions and people will see the harm"* [P5/ university professor].

Many of the interviewees believed that research should be purposeful and lead to decisions. A participant stated that:

TABLE 2 Identified challenges that required changes in Iran's healthcare system.

Theme	Subtheme	Code
Strengthening the electronic health infrastructure	Health Information System's integration	Multiplicity of information systems
		Duplicate information
		Tiering data access
	Data accuracy	Correct analysis of data
		Enhancing the authentication process
		Data quality
	Comprehensiveness	Process for collecting data
		A lack of complete data reporting
		Health data integrity at all levels
	Security	Users with specified access
		User validation
		Improving the security of health information
Dedicated pandemic financing	Consideration of a dedicated pandemic control budget	Lack of specific budget line for crises
		The Ministry of Health does not adequately fund medical sciences universities in order to manage pandemics
		Hospital revenue reductions and related problems during the pandemic
	Reforming the health financing system	Payment system reform
		Transparency and efficiency in the allocation of special pandemic funds
		Health expenditures per capita are declining
Research for evidence-based decision making	Applied research in health and prevention	Expanding access to data for researchers
		Orienting researchers' attitude toward applied research
		Multidimensional analysis of evidence
	Preparing a national road map for research	Future research of infectious diseases
		Research needs assessment according to the health status of the society
		Presenting research projects in policy making committees
Prevention of disruption in the effective provision of services and medicine	Development and implementation of clinical guidelines	Evidence-based pharmacotherapy with a focus on strengthening guidelines and training
		Update according to the change of disease variants
		Formulation of guidelines using health technology assessment
	Improving service delivery	Preventing service delivery disruptions for other diseases by focusing on public education
		Private sector participation
		Priority of prevention instead of treatment
		Modifications to the basic package of health services
	National diseases surveillance system	Strengthening the laboratory network
		Infectious disease syndromic improvement
		Infectious disease control center management needs to be strengthened and improved
		A clear report on the side effects of vaccines

(Continued)

TABLE 2 (Continued)

Theme	Subtheme	Code
Enriching the authority of the Ministry of Health by focusing on interactions	Restructuring Health Ministry decision-making and policy	Resolving multiple voices in decision-making at the national level
		Decentralization of decisions at the regional level
		Decision-making conflict of interest
	Strengthening national and international interactions and advocacy	Use of non-governmental organizations
		Strengthening the health ambassadors' program
	Coordination between the internal and external sectors	Horizontal integration in service delivery
		Vertical integration in service delivery
		Improve referral levels
		Strengthening external-sectoral coordination with a focus on increasing the power of MOHME
	Social marketing in COVID-19	Attracting public trust
		Public participation
		Society's obedience to the laws
Recruiting, managing and empowering health human resources with attention to financial and non-financial incentives	Continuous education of health sciences	Expansion of specialized training related to the pandemic
		Creation of crisis education core
		Continuation of "health in disasters" training all the time
	Strengthening the financial benefits of the health workforce	Payment problems
		Job insecurity
		Allocation of financial rewards for frontline health worker
		Process facilitation for staff
		Communicating with employees in a standardized manner
Reforming educational approaches in training students	Alignment of education and the health system	Changing and updating educational protocols
		Changing the curriculum of medical education according to family medicine
		Health faculties should incorporate a health department
	Changing the practice of health students due to the effects of the pandemic	Revealing the necessity of field work for students
		Pandemic as a golden opportunity
		Development of virtual education
Lessons learned from neglected aspects	Unused capacities, especially the primary health care system	Increasing active centers providing primary health care services
		Task shifting
		Paying attention to the role of the health network in promoting the health literacy of the community
	Planning and modifying infrastructures to deal with possible future pandemics	Completing the organizational positions of the healthcare network system
		Using epidemiologists in the health network
	Strengthening the Center for Infectious Disease Control and Prevention	CDC strengthening its position in the accreditation of health care facilities
		Modifying organizational charts related to the management of infectious diseases
		Inefficient policies

> *"During COVID-19, the research departments had the least cooperation and preparation, and in this field, now that we have passed the peak of COVID-19, it should be thought about making research more practical"* [P16/ Faculty member].

In the field of health research, it is a challenge that less attention is paid to the practical aspects of research. Despite conducting applied research, the results may not be incorporated into health policy formulation. For making health policy

decisions, there may not be a scientific roadmap. In post-COVID-19 era, it could be considered, According to one of the participants with academic and managerial experience in the COVID-19 crisis:

> *"... actions must be taken, one of them is decision-making based on scientific evidence, for this we must have a research mapping, that is, in research, we must first extract specific questions that are necessary for policymaking, then we will turn these into a proposal or an RFP order, then these will turn into a series of scientific proposals, and these proposals must come to the scientific committees and the scientific committee will turn them into policies.*

The participants stated that it is necessary to analyze the statistics with a multi-faceted perspective and decide about the risks may impose on society. One of them said:

> *"The next point is the lack of proper data analysis. If we do not analyze the data correctly, we will make an error in the conclusion. Statistics need technical analysis, and it is not the work of one person, and it should be looked at from different perspectives... we need to have the right indicators for risk assessment, that is, to make a wise decision according to the level of risk in the society, if we can control the risk by closing one class, there is no need to close all schools"* [P11/ health policy maker].

Dedicated financing to the pandemic

Dedicated financing includes two sub-themes as follows: consideration of a dedicated pandemic control budget and Reforming the health financing system. Most of the participants stated that during COVID-19 pandemic, the MOHME did not have enough financial resources and these minimal resources were not properly allocated.

> *"...we did not have money, the money we earned was given to us in installments, unfortunately, it came too late and lacked transparency, lack of timely allocation, financial corruption occurred and even the allocation was not efficient"*

Participants agreed that MOHME's budget should include a specific line item for health crises. A participant with work and research experience in primary health care stated:

> *"There is no budget under the title of crisis management in MOHME, whatever it is, this budget is current, and you should allocate the money that comes for normal times to the crisis"* [P10/ executive director].

There are two main payment systems in Iran's health system: fee-for-service and fixed salary payments. This is one of the most significant financing problems in Iran's health system. There are numerous evidences of the inefficiency of this system, yet there is no willingness to correct it. This can be attributed to the treatment-oriented approach and the absence of evidence-based policymaking in the Ministry of Health's executive decisions. Likewise, health expenditures per capita have decreased in recent years. In this regard, one of the participants with experience in policymaking said:

> *"... the first factor was the sanctions and the economic undersecretaries. In the World Bank category, I dropped from the higher middle-income category to the LMC category as our GDP dropped. On the other hand, the payment system is inefficient at the specialized levels and does not provide the necessary efficiency. The group related to diagnosis has been proposed for years, but it is still being implemented incompletely. It seems that one of the most significant decisions of health policy makers in the post-Corona era should be the reform of the payment system".*

Prevention of disruption in the effective provision of services and medicine

This theme includes three subthemes as follows: Development and implementation of clinical guidelines, Improving service delivery and National diseases surveillance system.

The interviewees believed that the unavailability and irrational prescription of important medicines were the main challenges of the COVID-19 crisis. One of the interviewees said:

> *"...sometimes medicines like Favipiravir were proven ineffective, but they were still prescribed or used. It seems that we did not have proper guidelines in this field, or the treatment staff was not given full and timely training; Or, for example, remdesivir is effective only in the viral phase of the disease, but we saw that it was prescribed for everyone, which would have caused a waste of resources, and its complications and side effects would have been problematic" [P9/ health policy maker].*

Another challenge during pandemic management was the inefficiency of some medicines for COVID-19 that would be covered by insurance. Nevertheless, the financial problems in the pandemic were exacerbated by spending on imported medicines that were not in compliance with international guidelines. A participant with experience in health policy said:

> *"Among the problems were the high cost of medicine and the lack of full support from insurance. The real need was more than the stock and caused the creation of a black market, so that sometimes a person had to spend more than several times the actual cost for medicines. The problems of economic sanctions should also be added to this issue, because of the sanctions, our access to some raw materials and medicines was limited"*

Another major challenge was providing services simultaneously for those suffering from COVID-19 and other diseases. One of the participants said:

> *"We did not have dedicated human resources for this issue, so I did task shifting, for example, Behvarz* (multi-professional rural health worker of Iran's health system*) who are the main foundations of care, we had to reduce some of their tasks and duties, and shifted them specifically to COVID-19 for rapid identification, isolation and formation of rapid response teams... as a result, many of our routine services were disrupted, for example, we saw a drop in diabetes and blood pressure care"* [P17/ deputy health official].

One of the other participants claimed:

> *"According to the studies conducted at Shiraz University of Medical Sciences, it was found that the services of pregnant mothers, children and diabetes have been disrupted and referrals have decreased compared to before the pandemic, which is partly due to people's fear of going to medical centers and...the solution that can be found in this field is one to get help from the private sector to provide services and second is to educate people about the need to refer and receive essential services such as routine vaccination or care of pregnant mothers"* [P15/ Faculty member].

Another sub-theme mentioned by the interviewees was focusing too much on treatment and neglecting prevention. A participant mentioned:

> *"If you check the countries that are successful in this field, you will see that they can control the pandemic and reduce the burden of hospitalization by relying on extensive testing and active disease detection. This required allocating resources to the health department, which unfortunately was not done"* [P12/ Faculty member].

The participants believed that there should be a monitoring system of the community's health status in the field of communicable and non-communicable diseases, so that changes can be monitored at regional and national levels.

> *"It seems that in the structure of the health network, there is a need to create a monitoring department, responsible for monitoring infectious, non-infectious and occupational diseases"* [P10/executive director].

Another participant added:

> *"If the monitoring center is established in the infectious diseases management unit, it can be a successful policy for the post-COVID-19 era and facing the next pandemics" [P19/ deputy health official].*

The lack of well-equipped laboratories in the provinces was one of the problems faced by the Iranian health system during the pandemic. In this way, laboratory tests for COVID were sometimes delayed and the golden opportunity to control and prevent the disease was lost. Participants with executive management experience in the field of health and prevention expressed an interest in this topic.

> *"The main laboratory was all in the center, and to diagnose new cases, samples had to be sent to the center, which made the care identification process very difficult. It seems that one of the most important actions of MOHME after the pandemic should be to equip and improve the country's laboratory network"*

Enriching the authority of the Ministry of Health by focusing on interactions

Enriching the authority of MOHME by focusing on interactions includes four subthemes as follows: Restructuring Health Ministry decision-making and policy, Strengthening national and international interactions and advocacy, Coordination between the internal and external sectors, Social marketing in COVID-19.

The participants believed that MOHME did not have enough political power to make effective decisions. One of them said:

> *"The most important challenge of governance is the lack of unanimity and lack of focus in decision-making. This means MOHME should have full responsibility and all departments related to the pandemic should be subject to the Minister's decision, which was a serious challenge during the COVID pandemic. For example, there was not much consensus on vaccination or closing schools and universities, and the opinions of MOHME were not considered significantly" [P18/policy maker].*

While there is a need for unanimity at the national level, some of the interviewees pointed out the necessity of decentralization for regional decisions, one of them said:

> *"All decisions regarding the health of regions should not be made by MOHME and can be delegated to the regions, this top-down decision-making structure is very problematic... if MOHME wants to act centrally, it will not succeed in controlling epidemics, because Iran has different cultures, behaviors, and climates. Someone in Tehran should write a version that will benefit both Sistan Baluchistan and Fars, it is not answerable and useful, regional management and decentralization should be on the agenda" [P14/ health policy makers].*

One of the major weaknesses that the interviewees agreed upon was the lack of internal and external coordination in the Ministry of Health, one of the participants stated:

> *"Regarding coordination, I have a negative opinion, that is, coordination within the health sector, that is, between different levels, i.e., coordination between primary care and our treatment levels should exist... Of course, it cannot be said that there is a lack of coordination, but it can be said that the communication was not effective, this communication should be discussed in the form of structure and process, it was like this before the pandemic, neither our structure is basically a continuous structure, nor are the processes defined continuously"* [P14/health policy maker].

Participants reported that one of the structural weaknesses in the management of the pandemic was the lack of appropriate external coordination. Therefore, it was believed that MOHME was not able to ensure that policies were being implemented effectively.

Due to this situation, preventive policies are not implemented, such as gathering or traveling bans, or even complying with protocols such as wearing masks.

> *"The most important lesson learned is that the responsibility of MOHME should be strengthened. In the beginning, the National Corona Headquarters was formed by the Minister of Health, all organizations had to come, several meetings were held. But they did not pay much attention to the words of the Minister, and at the end, the President himself became responsible for the National Corona Headquarters, because the influence of MOHME is weak" [P19/ deputy health official].*

Someone else added:

> *"Even we do not have intersectional collaboration, which means that there is no necessary coordination between the health system and other systems outside. This coordination was not there before; it only got worse during the pandemic"* [P17/ deputy health official].

The lack of advocacy at the national level and the weakness in international relations was a critical challenge in the recent pandemic. One of participants claimed:

> *"SUMS was praised many times for its management, the reason was that the management of the university had very good interactions and was able to attract the necessary advocacy"* [P5/ university professor].

Another participant stated that:

> *"Our international relations have problems in the field of epidemics, now we find that everything we have measles is from Afghanistan… for example, if you live in America now, they will give you a list of diseases of a certain country, get these vaccines, take these medicines with you, it means strong communication that gives them an exact list of health hazards"* [P7/ executive directors].

The need to gain people's trust and participation was another sub-theme mentioned, one of the interviewees said:

> *"Transparency is very important, we did not explain to the people why, for example, the schools should be opened, we should show the evidence to the people, if this happens, I think the people will accept and support"* [P1/ university professor].

Similarly, another participant maintained:

> *"You should inform the people about the danger that threatens them, this will enable people's participation"* [P11/ health policy maker].

Governance transparency is one of the most effective management tools during pandemics and similar crises. If used correctly, it can contribute to the successful implementation of health policies. In this context, one of the participants stated:

> *"In a pandemic, there is an important issue under the title of risk communication and community participation, which means that you should inform the people correctly about the danger that threatens them. You can provide risk communication and the possibility of public participation. This requires building trust and transparency. There was no single spokesperson in MOHME, and different voices from the Ministry of Interior and the MOHME were heard in this field. People were confused about this. It used to be that about 30 people in some way announced themselves to MOHME and the health system and made comments, and this led to confusion... As a result, people lost trust, whereas they had strong trust at the beginning of the disease outbreak. We published a study in March 2018 that showed people have the highest level of trust in radio and television regarding Corona virus transmission but were unable to maintain this trust"* [P8/ Faculty member].

Recruiting, managing, and empowering health human resources with attention to financial and non-financial incentives

This theme includes two subthemes as follows: Continuous education of health sciences, Strengthening the financial benefits of the health workforce. The optimal allocation of human resources and the use of specialists in their positions is one of the challenges of Iran's health system in the field of human resources. Meanwhile, temporary contract workers and their lack of job security are also among the concerns of human resources in the health sector. In the post-Corona world, one of the most important actions of the Ministry of Health should be to complete the organizational charts by using permanent personnel and paying attention to occupational health issues. One participant pronounced:

> *"Not only in the case of COVID-19, the use of human resources in the entire health system is not optimal. For example, look at the central building of the university, more than 350 nurses and doctors are working in the administrative area! That is, instead of being in the treatment and service department, they are doing simple administrative work"* [P2/ health policy maker].

Furthermore, a participant stated:

> *"One big challenge is the supply of forces, and the other is the quality of the forces. And let's divide the human forces into two categories, the forces that can work professionally in a pandemic, such as a nurse who has worked in the respiratory department and has expertise in this field, or a lung or infectious disease specialist, and the second category is general forces"* [P13/ health policy maker].

Another participant maintained:

> *"The important point in this pandemic was the lack of training for these forces. One of the necessary tasks and plans is training of these forces"* [P6/ deputy health official].

In addition, another participant stated that:

> *"We should invest especially on pandemics and crises management.… this issue should be part of continuous education in the health department and should not be neglected"* [P14/ health policy maker].

Another participant continued:

> *"The second issue is motivation for human resources, which should be given special attention. For example, during the COVID pandemic, many of the personnel were not appreciated as they*

should be, and immediately after the COVID subsided, sometimes even their contracts were not renewed, or they were even given very little bonuses" [P8/ Faculty member].

Reforming educational approaches in training medical students

This theme includes two sub-themes as follows: alignment of education and the health system and changing the practice of health students due to the effects of the pandemic. One of the issues raised in this study was the strengthening of public health and related academic disciplines. The participants believed that this strengthening should be done in the context of changing the curricula of academic disciplines of public health and merging parallel educational centers in order to increase the influence of health faculties in the field of prevention and public health.

> *"We must start the change first from the university and the health fields. It has been more than a decade now that the curriculum of the public health field, which is the executive arm of the health network, has not been updated".*

In this regard, one of the participants with academic and research experience in primary health care stated the following:

> *"Unless the students work at the bedside, they can't become a doctor. They can't be a driver until they sit behind the wheel, in health sciences, no one can claim to know the work without being in the field. I think that systematic planning should be done by health faculties for the participation of students in the field to really learn. Being in the field is a golden opportunity and an unforgettable experience"*

The alignment of education and the health system, as well as the integration of parallel education centers into the network system, was identified as a sub-theme. One participant said:

> *"In the health network system, we have a training center for behvarz* (multi-professional rural health worker of Iran's health system)*, but these centers are not connected to health schools. By integrating these educational centers into university, one of the basic changes can be achieved in improving the scientific and academic level of this group. In contrast, Health Vice-Chancellors have practically no relationship with health colleges, even if the forces trained in the colleges are ultimately recruited into these vice-chancellors and subgroups. To improve the presence of students in the field and to strengthen the network system of Health Vice-Chancellors in colleges, it is important that health is integrated" [p6/ deputy health official].*

One of the sub-themes identified was changing the education and training methods of medical students based on PHC:

> *"We train medical students with a hospital approach, but we have no basic training in prevention and family medicine at universities, so we bring these physicians to health centers and expect them to work according to PHC goals. Changing the curriculum of medical education or training general doctors for family medicine from the beginning would be a good idea". [p15/ Faculty member]*

Lessons learned from neglected aspects

Learning lessons from neglected aspects includes three sub-themes as follows: Unused capacities, especially the primary health care system, planning and modifying infrastructures to deal with possible future pandemics and strengthening the Center for Infectious Disease Control and Prevention. As one of the main management units during the pandemic, the Center for the Control and Prevention of Infectious Diseases of the MOHME did not play a prominent role, it seems that the unit has been weakened by some wrong policies over the past few years, and serious reform is needed.

> *"To deal with COVID-19, we needed a series of basic infrastructures that we did not have, such as a preparedness plan for pandemics, crises, and general epidemics. To do this, the Centers for Disease Control and Prevention must be agile, dynamic, and strong. It is not too late because our country is in an area that could experience other epidemics in the future"* [P11/ health policy maker].

Regarding strengthening the Center for Control and Prevention of Infectious Diseases, one participant said:

> *One of the basic measures in the post-COVID era is to strengthen the management of infectious diseases. Our infectious disease control and prevention center has been weakened and neglected for various reasons before the outbreak of COVID-19. In my opinion, policy makers should prioritize this issue* [P9 health policy maker].

Despite regional conditions, policies at the Center for the Control and Prevention of Infectious Diseases weakened its subdivisions. One of the wrong policies before the pandemic was changing the organizational charts of the first-level service centers. These decisions did not seem to be based on scientific evidence:

> *"It was a mistake to change positions, such as removing disease experts, in the health and treatment network. Our health policy makers believe that noncommunicable diseases are the main challenge we face, and vaccines and epidemiological trends have ensured that communicable diseases aren't a problem, but the COVID pandemic proved this wrong"* [p10/ executive director].

The participants believed that, although the overall capacities to respond to the COVID-19 crisis were low, these minimal capacities were not properly used. One of the interviewees claimed:

> *"Sometimes we even saw that up to 20% can be added to the service delivery capacity of a treatment unit, so managing resources in a crisis is of particular importance"* [P15/ Faculty member].

Similarly, another participant said:

> *"The capacities of the government and hospital sectors were full, and patients were dying because of this, and they could not coordinate the capacities of the private sector to come and provide services"* [P11/ health policy maker].

Another major challenge was inefficient decisions and policies, one of the interviewees said:

> *"The control policies announced by MOHME were practically not a deterrent, for example, the fines considered for inter-provincial traffic were small amounts that did not have the ability to deter and control and were practically ineffective"* [P16/ Faculty member].

In general, the interviewees believed that Iran is a high-risk country and should be prepared to face the next possible crises both in terms of infrastructure and planning. A participant said:

> *"The structure that is ready to face the crisis was not designed even on paper, for example, the laboratories were all in Tehran, that is, only one laboratory of the Pasteur Institute had been seen for these situations and there was none anywhere else in the country"* [P4/executive directors].

Besides, a participant asserted:

> *"We wanted a series of basic infrastructures that we did not have, such as the readiness of our health system to deal with pandemics and crises. This issue requires an agile, dynamic, and strong CDC, up-to-date and with dynamic thinking. It's still not too late because our country is in a region that has the chance of encountering other epidemics. Our country is the meeting point of three epidemiological zones, which means we are at risk, the variety of diseases is high, we are not in an interesting situation from a geopolitical point of view, illegal traffic is rampant in many borders" [P2/ health policy maker].*

Discussion

The results showed that the areas that need to be improved in Iran's healthcare system because of the COVID-19 pandemic can be expressed in eight main themes. Each of these themes are discussed below to show the paradigm shift's requirements in Iranian healthcare system.

Strengthening the electronic health infrastructure

The present results explore the necessity of the creation of a comprehensive and integrated health information system with accuracy and data security. Other evidence also emphasizes that the integrated electronic health record environment can provide a basis for consistent and verified access to basic information through the Internet to support decision making (20). Another study emphasizes that the privacy of patients and the security of their information is the most necessary obstacle for the adoption of e-health, and it points to the necessity of security techniques at three administrative, physical, and technical levels (21). Despite the importance of electronic health record data, less attention has been paid to the quality of the data. Keshta et al. in a study with the aim of evaluating the quality of the records of COVID-19 patients in the health information system, explored that ICD-10 codes were incorrectly assigned to the records of 238 patients (72.56%). More attention to data quality assessment as a prerequisite for patient safety and data readiness for research and predictive analysis, along with training healthcare providers about the importance of accurate documentation were among their recommendations (22).

Other results of this study emphasize providing a database with a certain level of access for decision makers at different levels with the aim of facilitating the evidence-based decision-making process. As other studies imply Ministries of Health in low- and middle-income countries often do not have access to high-quality and timely data. Lack of an organizational culture for data-driven decision-making is reported as well (23, 24). Data-based decision-making at different levels and in different areas of healthcare, including planning, procurement, and operations, providing health care between individuals, can effectively determine priority decisions (25).

Other related results in this area refer to the necessity of strengthening telehealth infrastructure. Telehealth is an efficient solution for healthcare delivery and has the potential to address many health systems challenges. But before the shaking of the health systems by COVID-19, little attention was paid to the implementation of telehealth. The evidence indicates that the implementation of this strategy requires the strengthening of infrastructures at four political, technological, organizational, and individual levels (26).

And the last result here is related to the use of intelligent systems for decision making. The present results clarify the need to use such systems in the field of clinical and political decisions. Other studies have also shown that intelligent systems can help decision makers improve the effectiveness of their decisions by integrating data mining techniques and model-based systems (27). In addition, other researchers emphasize that the use of Intelligent Decision Support Systems (IDSS) can have powerful help in solving difficult problems. These tools help overcome cognitive limitations and human biases and provide logical support to decision makers (28).

Research for evidence-based decision making

One of the most fundamental challenges in the evidence-based decision-making process was the limitations of data access for researchers. In this regard, other studies have also pointed to the challenges of sharing health data with researchers during the COVID-19 era, which can lead to potentially harmful effects for citizens. The most important obstacles identified were legal conflicts between fundamental rights and data protection laws (29). Similarly, another researcher stated that one of the limitations of evidence-based decision-making in Iran is the lack of access to evidence (30).

Other results of this area were related to promoting the attitude of conducting applied research among researchers. Relevant evidence shows that the existence of research topics that generate sufficient interest in both the research and the policymaking communities and

constructive collaboration among them may lead to increase the probability of conducting applied research and integrating research evidence into policymaking (31).

Preparing a national road map for research is among other results here. Other researchers emphasize that the 21st century is the era of expansion of infrastructure and research roadmap. By using the research roadmap, it is possible to understand knowledge gaps, determine the direction and perspective of national research, reflect emerging research opportunities and challenges, provide important national facilities and services to support research and innovations, and help government decisions (32, 33).

Detailed data analysis with a multifaceted approach to determine the level of risk is mentioned among other results of the study. Similarly, another study showed that due to the complex nature of COVID-19 and its different effects on different groups, the response to the crisis should be accompanied by systemic thinking and a multifaceted approach with the participation of different organizations and people (34). In this regard, many other studies implied that due to the multifaceted nature of COVID-19, there should be a multifaceted treatment approach in the risk assessment and treatment of this disease (35). And similarly, a multidimensional approach should be taken in evaluating the fears related to this disease in society (36). Decisions must be accompanied by a holistic approach, an approach that integrates biomedical, psychoeducational, sociocultural, and justice perspectives. Applying this balanced approach to decision-making will help increase consistency and ensure that all viewpoints and concerns are considered (37).

Dedicated financing to the pandemic

Among other challenges identified in this research which require particular attention, we can refer to the lack of special budget for pandemics in Iranian's healthcare system and lack of transparency in the resources spent in this area. Evidence shows that in response to the COVID-19 pandemic, many countries have reprogrammed their existing budgets while others have activated emergency reserves, considered supplementary budgets, or created extra-budgetary dedicated funds. There are various motivations behind the creation of these funds, one of which is to separate the costs of COVID-19 from other expenditures, thereby increasing financial transparency and accountability, and creating a well-defined audit trail. It has also been suggested to use certain performance indicators to evaluate the economic impact of EBFs (extra-budgetary funds) (38, 39).

Prevention of disruption in the effective provision of services and medicine

Disruption in the provision of health services not only to COVID-19 patients, but also to other non-COVID-19 patients was another challenge. Restrictions on medical access and the creation of a drug black market due to economic sanctions have been considered as one of the fundamental challenges in the Iranian healthcare system in recent years, which worsened during the COVID-19 pandemic. Other evidence also shows that the sanctions have faced about 6 million Iranian patients with limited access to treatment and vital medicines. As a result, an unregulated black market has been created to compensate for drug shortages, offering drugs whose origin and authenticity are often unknown, expired, and sold at a much higher price than the actual price (40).

The next result refers to prescription without scientific support, which shows weakness in training and developing guidelines. Even before the beginning of this crisis, studies have shown that a very large percentage of therapists in Iran do not have access to databases for evidence-based medicine (41, 42). Also, the previous evidence indicates the weakness of Iran's healthcare system in the development, localization, distribution, and implementation of clinical guidelines (43). This age-old challenge has worsened in the era of COVID-19. Another study has also confirmed that evidence-based medicine has been shaken during this pandemic and doctors' trust has been eroded due to disagreements in scientific evidence and the publication of misleading scientific articles about COVID-19 (44).

Another identified weakness that needs to be strengthened was the disruption of services to other non-COVID patients. The results of this study indicate that by using existing potentials and changing procedures in the government sector, as well as seeking help from the private sector and increasing public awareness, this problem can be solved to an acceptable extent. Other studies have also shown that other non-COVID cares, especially routine ones (not emergency), were the most vulnerable, and had the most cancellations or postponements (45, 46). The shift of resources toward COVID patients and the lack of hospital beds, the diversion of staff from normal services to COVID services, along with the high public fear and anxiety of crowded places, all led to limited access to other non- COVID health services (47, 48). In response to this challenge, some centers divided their personnel into employees in COVID-19 zone and employees in COVID-19 free zone. Some centers, relying on the same existing resources, have used telemedicine as a tool to provide services and protect patients against COVID-19 (47, 49). The solution of some countries was to use the capacity of the private sector to access COVID-19 services, especially laboratory services (50). In general, governments' strategies to engage with the private sector developed rapidly, however, monitoring was often weak, indicating the weakness of governments in ensuring cost-effective and high-quality private services (51). To reduce the raised fear and concerns, the use of targeted training to deal with fear, and the expansion of mental health support have been suggested (52). In this regard, some studies have pointed out the influence of the media on increasing people's awareness and its role in the healthy behaviors needed in the era of COVID-19 (53).

The study participants emphasized the need for a prevention-oriented approach, so that this issue is considered in health policy and practice. Practical aspects of this approach include allocating financial, human, and physical resources to health networks and strengthening their infrastructure. This problem has already existed, and it became very troublesome during COVID-19. The healthcare system in Iran has a treatment-oriented approach, and prevention ranks second. Therefore, the priority of the healthcare system is to provide and increase the number of hospital beds, and community-oriented care and disease prevention have no place (54). While efforts focused on reorganizing and strengthening hospitals, primary and community care was largely neglected. Evidence shows that even the best hospital system could not cope with the demand caused by COVID-19 and social and home primary preventive care would

have led to the reduction of this epidemic. As an example, Greece pursued the strategy of focusing on hospital preparedness but failed to strengthen primary care. This condition along with the country's strategic mistakes in epidemiological surveillance led to a case with the highest death rates from COVID-19 in Europe during the second wave (55).

Another identified weakness that needs to be strengthened is the lack of a specific structure in Iran's healthcare system to monitor the status of communicable and non-communicable diseases. As evidence in many countries suggests disruption of services to non-COVID patients (56, 57), particularly patients with non-communicable diseases (58), the present interviewees believed that this neglect is problematic and other diseases should also be taken into consideration in the national response to COVID-19. This requires the existence of a monitoring structure to determine the status of these diseases. The World Health Organization (WHO) considers it necessary to create this system for a comprehensive response to the pandemic, because it provides the possibility of monitoring vulnerable or at-risk populations and tracking epidemiological changes, which leads to effective response (59). On the other hand, delays in chronic care treatments, high numbers of deferred surgeries, and increases in mental health problems suggest a less visible epidemic that is quietly spreading and destroying people's lives, while COVID-19 gets all the attention (60, 61). Maybe a comprehensive surveillance system for other diseases can partially reveal and control the silent and possible pandemic ahead.

There was a mention of the weak laboratory network in this study, which requires an extensive infrastructure. Other studies have also pointed to the weakness of laboratory services during the COVID era due to lack of equipment because of sanctions, weak infrastructure, and laboratory scientific knowledge in Iran (62, 63).

Enriching the authority of the Ministry of Health by focusing on interactions

One of the mentioned issues is solving the multi-voice problem in macro-decisions. Regional differences and the necessity of decentralization in regional decisions should not be forgotten. Although to make an effective decision, the preferences of all stakeholders should be considered and multi-voice decision making should be used (64), it is necessary to be aware of the complex role of powers in political processes and consider mechanisms to manage the influence of these powers, in a way that political interactive dialogues are directed toward strengthening priority programs (65). Another study also pointed to the complex network of key decision makers in this pandemic and the influence of international norms and political competition. In this regard, to control conflicts, increase legitimacy and protect against mismanagement, and increase the effectiveness of decisions, some countries have organized the National Committee for COVID-19 consisting of related ministries and headed by the Prime Minister, and they formed similar committees at the regional level (66).

The next sub-theme refers to advocacy and increasing political interactions at the national and international levels which can facilitate the previous sub-themes. Iran's experience in recent years shows many challenges in the healthcare system due to weakness in international political relations and sanctions (67). Since the beginning of the pandemic, the necessity of determining the key principles of international relations and attracting political support at different levels has been pointed out, and "lack of leadership and solidarity at the global and national levels" has been introduced as the biggest threat of this pandemic. In this regard, WHO, like an international magnet, strengthened relations between countries and controlled governments by developing international health regulations, and connected global and national reactions and decisions with different interactive patterns (68).

In the next sub-theme, the internal coordination of the healthcare system and the strengthening of the referral system are mentioned. To ensure the effective implementation of measures, WHO recommended the necessity of careful monitoring of service delivery patterns–especially for essential health services- and coordination with relevant authorities to establish coordination between public and private service providers and determine referral pathways. In addition, in these recommendations, the need for coordination within the system to ensure proper referral for testing, isolation and admission to the hospital is also mentioned (69).

In the next sub-theme, coordination between the MOHME and other organizations is mentioned. Other studies have pointed out that the scale of the pandemic requires coordination of efforts across government sectors as well as non-governmental organizations. For the health sector, this means horizontal (with other ministries, with relevant non-governmental actors and across borders) and vertical (at central, regional, and municipal levels) coordination in decision-making. Horizontal and vertical coordination seems necessary for aligning policymaking and implementation (70). Another study explored many shortcomings in the global response to the COVID-19 pandemic including the failure to coordinate efforts across geographic regions, within and between countries, ranks near the top of the list of poor performance (71).

The need to gain public trust is another mentioned issue, which can bring people's participation and their greater compliance with the laws. A study compared Indonesia's president's admission of delayed public risk communication for fear of the economic cost with Iran, where secrecy has certainly contributed to a rapid increase in the death rate. This led to people's severe distrust of the government's reporting system and its response capacity (68). In another study, it is explicitly stated that "your government needs you." In this research, in response to the pandemic, the necessity of designing technology systems has been pointed out, and in the design of these systems, the necessity of the participation of people who use the systems daily has been pointed out (71).

Recruiting, managing, and empowering health human resources with attention to financial and non-financial incentives

The effective provision of health services is strongly influenced by human resources. Results of this research showed that management of these valuable resources is one of the necessities that should be given more attention. Another study has also stated that one of the main challenges of healthcare systems against pandemic management was the challenge of recruitment, inappropriate number, type, distribution method and optimal management of human resources (11).

Inadequate knowledge of health workers is mentioned which comes from two sources. The first is that in Iran's healthcare system, education related to disaster health had been forgotten for many years. Second, specific training related to the current pandemic was also provided in a weak manner. Based on the published research at the beginning of the pandemic, a significant number of health workers had poor knowledge of the ways of transmission of the disease and the initial clinical symptoms (72, 73). In general, insufficient preparation, lack of specialized knowledge, and lack of access to practical skills were among the challenges of health workers in dealing with COVID-19 pandemic (11).

In the next two sub-themes, the financial and non-financial support of the health workforce is mentioned. One of the most important challenges in the field of non-financial issues is mental health problems. Evidence suggests that personnel working directly in the COVID-19 units have experienced many psychological changes due to unpredictable conditions, high workload, unknown nature of the disease, frequent changes in protocols and policies (72, 74). And in general, during the COVID-19 pandemic, negative psychological effects such as stress, depression, anxiety, insomnia, and feelings of anger have increased among healthcare workers (75). Using mental health consults and support for health workers during disasters, and empowering personnel's skills in managing stress and negative emotions can help reduce mental disorders (11). In the field of financial issues, delays in payments and lack of sufficient financial incentives were among the problems that need to be addressed. Similarly, another study has pointed out that public hospitals have faced many problems that led to a reduction of their financial ability to provide support facilities for personnel (76). It has been shown that in Colombia many hospitals have been forced to lay off their staff due to increased costs and loss of income during COVID-19 (77). On the other hand, nurses in Iran have also complained about the delay in payment of service compensation and the small payments they have received regarding their heavy duties (72).

Reforming educational approaches in medical students' training

Another issue that needs to be addressed more is the training of students in practical work fields. Due to the unique structure of Iran's medical science system -a combined system of education, research, and service provision in universities of medical sciences- remarkable achievements can be made in the training of a skilled workforce that has experience working at the bedside since the student days (78). While it seems that in some fields of study, including health fields, this issue has not been realized as it should be.

Another issue that has been discussed for years, but practically nothing has been done about it, is the updating of the educational protocols of most academic fields. Several studies have been conducted on the impact of the pandemic on medical education (79, 80). Much evidence indicates that the usual methods should be changed, and training should be adjusted based on health protocols (81). Another study has pointed to effects and potentials of COVID-19 on medical education which led to revise the possibility of online learning, raise standards in medical education, and expand clinical learning (82).

Lessons learned from neglected aspects

One of the most important unused potentials in Iran's healthcare system was the structure of the primary health care network. While in recommendations to strengthen the response to COVID-19, WHO has pointed out the importance of primary healthcare to deal more effectively with the pandemic and has introduced this network as a unique opportunity to increase the impact of many actions and an integral part of the public health response to COVID-19 (69).

Another weakness that needs more consideration was the adoption of inefficient decisions during the COVID-19 era, this weakness was especially observed in control policies. Others have argued that policies may be ineffective or even backfire unless they get everyone to act. The spread of COVID-19 has prompted governments and public health authorities to move toward restricting new infections. Most of these interventions rely on community compliance, and if not implemented strongly across all social groups, compliance will be impaired and the policy ineffective (83).

In the next sub-theme, it is mentioned that infrastructures and programs should be created to deal with the next possible pandemics. COVID-19 has highlighted the need for a more ambitious and sustainable approach to planning and a stronger infrastructure for preparedness. Similarly, others have stressed the need to plan for the next pandemic (71). Others also emphasize that although the consequences and casualties of COVID-19 are significant, lessons learned should be considered. Events like the current pandemic will occur again in the future, will have unpredictable characteristics, and will pose a great threat to all countries from a health, economic and social perspective. The only possible solution is to further strengthen the readiness of countries by obtaining political commitment and pre-planning (84).

Conclusion

In summary, the present study revealed the need for a paradigm shift in various aspects of Iran's healthcare system. COVID-19 is not the first pandemic, and it will not be the last, and we will not be prepared for the next one unless we take bold steps. It is necessary to move toward e-health in step with advanced countries and provide the culture and infrastructure of evidence-based decision making. In addition, dedicated budgets for pandemics should be considered in the funding structure of MOHME, and by focusing on the challenges of providing services in the current pandemic, prevent this disruption in future outbreaks. Interactions at the national and international level should be given more attention and the power tools of MOHME, as the custodian of pandemic control, should be strengthened. Also, healthcare workers as valuable resources in pandemic management should be given special attention from all financial, non-financial and educational aspects. Furthermore, the effective training of future human resources, current students, should not be neglected either. And finally, one should think about which existing potentials have

been neglected, apart from the basic weaknesses, and prepare for the next pandemics.

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.

Ethics statement

The article's proposal was approved by Ethics Committee affiliated with Shiraz University of Medical Sciences with the ID of IR.SUMS.REC.1399.1038. The informed consent obtained both in written form and verbally before starting interview and the Ethics Committee approved this procedure with the above ethical code consent for publication. The patients/participants provided their written informed consent to participate in this study.

Author contributions

MM: study design, data collection, data analysis, accrual of study participants, and writing and reviewing the manuscript. PB: study design, data analysis, accrual of study participants, reviewing the manuscript for critical revisions, and important intellectual content. SD: data analysis, accrual of study participants, and critically revising the manuscript for important intellectual content. ZK and MP: data analysis and accrual of study participants. RI: translation of the article and correction of grammar and language, data analysis, and reviewing the manuscript for critical revisions. All authors read and approved the final version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The knowledge, attitudes, and perceptions toward the Oxford AstraZeneca COVID-19 vaccine amongst Primary Health care workers in North-Central Trinidad

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Aim: To determine the effects of knowledge, attitudes, and perceptions of primary care health workers toward receiving the Oxford AstraZeneca vaccine in North Central, Trinidad.

Methods: A pretested *de novo* questionnaire containing forty-eight (48) closed ended questions and one (1) open ended question was used to gather data. Descriptive and inferential statistics were used to analyze the data obtained from the questionnaire. These included percentages, means and standard deviations for the descriptive aspect and the Chi-Square test to examine any significant associations. Analysis of Variance (ANOVA) was used to assess any significant differences in means among several categories and the independent samples *t*-test for assessing any significant difference in means between two categories.

Results: 273 respondents completed the questionnaire. Most of the participants (72.2%) were female and within the age range 25–36 (56.0%). The mean knowledge score about the AstraZeneca vaccine was 16.28 (SD = 2.28) out of 19 with an overall correct response rate of 79%. 30.4% of participants had a good attitude score and 59.7% had a positive perception toward the AstraZeneca vaccine. There were significant associations between knowledge and marital status ($p = 0.001$), income level ($p = 0.001$), education level ($p < 0.001$), and length of employment ($p = 0.041$); attitudes and sex ($p = 0.01$), age ($p = 0.04$), marital status ($p = 0.009$), income level ($p < 0.001$), education level ($p = 0.005$) and category of staff ($p < 0.001$); perception and sex ($p = 0.002$), marital status ($p = 0.027$), income level ($p < 0.001$), and category of staff ($p < 0.001$).

Conclusions: The main contributors to vaccine hesitancy were inadequate duration of clinical trials and fear of adverse side effects. A significant number of participants (17%) were unwilling to get the vaccine due to lack of information.

KEYWORDS

vaccination, COVID-19 pandemic, knowledge, attitude and practice (KAP), primary care (MeSH)

Introduction

The COVID-19 pandemic has had major implications worldwide. According to the Ministry of Health—Trinidad and Tobago (MOHTT), in February 2021, there were over 7,600 positive cases locally—including 136 deaths. In Trinidad and Tobago various public health measures were taken to reduce the spread of COVID-19. The key mitigation and containment strategies implemented by the country were evidence-informed and demonstrated an "all-of-government" approach (1). These measures included mask mandates, encouraging social distancing, frequent hand-washing and imposing limitations on the size of public gatherings. One of the most important steps of modern medicine in the prevention of infectious diseases is achieving immunity through Vaccination. Primary Health Care Services in Trinidad and Tobago joined the Global effort to provide vaccines to the population to reduce the burden of the COVID-19 pandemic. The Government of Trinidad and Tobago initially acquired 100,000–120,000 Oxford AstraZeneca COVID-19 Vaccines through the COVID-19 Vaccines Global Access (COVAX) programme (2). These vaccines were initially allocated to high-risk groups including front line health care workers.

Healthcare workers are viewed as reliable sources of information on vaccination as seen in multiple studies, locally and internationally. The success of a vaccination process is greatly determined by healthcare workers' acceptability, knowledge, awareness, and attitudes about COVID-19 vaccination (3). Popa et al. highlighted the role of primary care healthcare professionals, namely, family physicians in promoting vaccine acceptance (4). Locally, De Freitas et al. found that people with high levels of trust in the medical sector were less likely to believe in misinformation (5). Healthcare professionals, therefore, have a significant role in maintaining public trust in vaccination (3).

Furthermore, it has been observed that a negative attitude toward the vaccination process can serve as a Public Health barrier to the achievement of immunity in the population and interventions that address these concerns should be of great importance (6).

The varying attitudes of persons, whether influenced by demographics, ethnicity, educational or social standing, will affect the willingness of vaccination throughout the world. Several studies have been done in multiple countries exploring different attitudes and levels of acceptance of the COVID-19 vaccine among different groups of persons.

In the Democratic Republic of Congo a 27.7% acceptance rate of COVID-19 vaccination amongst healthcare workers has been reported. The willingness of health care workers in Congo toward COVID-19 vaccination was found to be very low when compared with a similar study by Fares et al. in France which revealed that 77.6% of participants "probably agreed" to get vaccinated against COVID-19. The Congo study highlighted that hesitancy is a major barrier to implementation of the vaccine and understanding and addressing vaccine hesitancy is important to maintain the benefits of vaccination programmes (7).

An Israeli study utilizing an anonymous online questionnaire stratified for health care professionals showed that being a healthcare professional did not significantly influence the participants' acceptance of the COVID-19 vaccine; however, doctors working in COVID-19 departments showed higher acceptance rates than those in other departments (8). Furthermore, doctors were generally more accepting of the vaccine than nurses. A significant positive predictor for acceptance of the COVID-19 vaccine was found to be acceptance of the influenza vaccine. This was also reported by Fisher et al. (9).

Safety issues are paramount amongst health care workers. Indeed, the greatest concern to health care workers was the safety of the vaccine with respect to its rapid development, in particular quality control, potential side effects and associated COVID-19 (8, 10).

The following factors were found to be strong predictors of COVID-19 vaccine hesitancy in healthcare workers (6, 8): low-income or unemployed groups, poor adherence to COVID-19 government guidelines, poor perception of disease risk, female gender, and having children.

Overall, a clear understanding of the reasons for vaccine hesitancy is vital in attaining long term control of COVID-19. There is currently no published data related to COVID-19 vaccine perception amongst health care workers. By assessing the healthcare workers' knowledge, attitudes and perceptions toward the Oxford AstraZeneca COVID-19 vaccination, new information becomes available to guide public health initiatives related to vaccine promotion and education.

Methodology

A cross-sectional study using a three scalar methodology was used to obtain data on the knowledge, attitudes, and perceptions toward the COVID-19 vaccine. A *de novo* questionnaire containing forty-eight (48) closed ended questions and one (1) open ended question was used to gather data. The questionnaire was pre tested during the last 2 weeks of April 2021 and adjustments made to reduce duplications and refine the questions for ease of administration. It was made accessible *via* an online form and completed during the period May 08, 2021 to July 21, 2021. The single open-ended question targeted the address of the participant. Three of the four sections of the questionnaire inquired into the knowledge, attitudes and perceptions toward the Oxford AstraZeneca COVID-19 vaccine respectively and the remaining section addressed participants' demographics (see Appendix 1).

Sample size calculation

Given the estimated total of 532 Health Care Workers distributed throughout the fifteen (15) primary care facilities within the region, sampling all clinical staff members was determined to be the best way to accurately reflect the KAP of the primary care staff.

For calculating the minimum sample size, the following formula will be used:

$$n_0 = \frac{z^2_{(1-\alpha)}\hat{p}\left(1-\hat{p}\right)}{D^2}$$

Where:

$z_{1-\alpha} = 1.96$ (the value from the standard normal distribution for an error of 0.05).

$\hat{p} = 0.5$ (the estimated prevalence- when unknown as in this case we will use 0.5).

$D = 0.05$ (the margin of error – 5%).

Therefore:

$$\text{Sample size} = \frac{1.96^2 x\ 0.5(1-0.5)}{0.05^2} = 384.$$

Sample specification

Target Population: Primary Care Health Care workers employed at institutions in the North Central Region.

Sample selection was Purposive sampling.

Recruitment methodology

A list of the total number of Health Care workers from primary care facilities within the North Central region was provided by the Regional authority governing the North Central Region, namely the North Central Regional Health Authority (NCRHA).

Inclusion criteria

Health Care workers employed at primary care facilities within NCRHA over the age of 18 years and consenting to participate.

Exclusion criteria

i.) Health care workers who refuse to participate.
ii.) Health care workers under the age of 18.

Ethical approval was obtained from the NCRHA.

Scoring knowledge, attitudes and perceptions

The participants' knowledge was assessed using a total of 13 questions. Four of these questions had a maximum of 2 points, 7 of the questions had a maximum of 1 point and the remaining 2 questions had a maximum of zero. Wrong answers were given a score of zero. The total scores to assess knowledge varies between 0 and 15 points.

The analysis of this section adopted the original Bloom's cut off points (80.0%−100.0%, 60.0%−79.0%, and ≤59.0%), which classifies participants into three categories as seen below:

12–15 points—good knowledge, 9–11 points—moderate, <9—poor.

The second module of the questionnaire assessed the participants' attitudes to the COVID-19 vaccine namely the Oxford AstraZeneca. There was a total of nine (9) questions in this section. Five (5) of these questions were interpreted in one of two ways; answers in support of the COVID-19 vaccine (AstraZeneca) obtaining a score of one and those against the COVID-19 vaccine (AstraZeneca) obtaining a score of zero. Four of the questions had a maximum score of zero.

As such, the total score for this section ranged from 0 to 5 and was then classified into participants with a positive attitude scoring more than or equal to 70% and participants with a negative attitude scoring <70%.

The third section of the questionnaire focused on the perceptions of the participants toward the COVID-19 vaccine. This was assessed using the Likert scale. There were eight positive statements and two negative statements. A five-point rating scale was used and contained the following categories and points scored for each:

Positive statements: Strongly agree (5 points), Agree (4 points), Neutral (3 points), Disagree (2 points), Strongly disagree (1 point).

Negative Statements: Strongly agree (1 point), Agree (2 points), Neutral (3 points), Disagree (4 points), Strongly disagree (5 points).

The maximum attainable score was 50 points. The tallied score was placed into one of the following categories: positive perception: 38–50 points, neutral perception: 25–37 points, negative perception: <25 points.

Statistical methods and software

The Statistical Software for Social Sciences, version 27 (SPSS Inc., Chicago, IL) was used for analyzing the data. Prior to data analysis, the normality was tested using the Kolmogorov—Smirnov and Shapiro—Wilks's test. Furthermore, the internal consistency of the Likert scale used for assessment of Attitude was investigated using Cronbach's alpha. Descriptive and inferential statistics were performed using the Chi-square to test for significant associations, the independent samples t-test and ANOVA were used for comparison of two means and more than two respectively. A $p < 0.05$ was deemed statistically significant.

Results

From the target population of 384, there were 302 participants of which 273 had complete responses. This gave a response rate of 71% from the sample size investigated. The internal consistency of the Likert scale used for assessment of Attitude was investigated using Cronbach's alpha which gave a result of $\alpha = 0.87$ indicative of good internal consistency.

Demographic data

Most of the participants (72.2%) were female and within the age range 25–36 (56.0%). Approximately half of the respondents (49.8%) said they were single and most had tertiary level education (89.7%). The majority were doctors (44.0%) and had been employed over 6 months (86.8%). Other demographic features can be seen in Table 1.

Source of knowledge about the AstraZeneca vaccine

The mean knowledge score about the AstraZeneca vaccine was 16.28 (SD = 2.28) out of 19 with an overall correct response rate of 79%. Using the Chi-square test, statistically significant associations were seen for knowledge and age ($p = 0.042$) marital status ($p = 0.001$), income level ($p = 0.001$), Education level ($p < 0.001$), NCRHA cluster ($p = 0.011$), category of staff ($p = 0.016$) and length of employment ($p = 0.041$). These results are depicted in Table 2. 186 (68.1%) of the participants had good knowledge, 81 (29.7%) had moderate knowledge and 6 (2.2%) had a poor knowledge score. As seen in Figure 1, the most common source of knowledge about the AstraZeneca vaccine was the internet (30%).

TABLE 1 Demographic features of the participants ($n = 273$).

Features		Frequency (*n*)	Percent (%)
Gender	Female	197	72.2
	Male	76	27.8
Age range (year)	18–25	9	3.3
	26–35	153	56.0
	36–45	54	19.8
	46–55	38	13.9
	56–65	18	6.6
	66 and more	1	0.4
Marital status	Common-law marriage	15	5.5
	Divorced	11	4.0
	Married	106	38.8
	Single	136	49.8
	Windowed	5	1.8
Education level	Secondary level	27	9.9
	Tertiary level	245	89.7
	Trade school	1	0.4
Occupation	Dentist	8	2.9
	Dietician	4	1.5
	Doctor	120	44.0
	EMT	1	0.4
	ENA	25	9.2
	PCA—patient care assistant	23	8.4
	Pharmacist	8	2.9
	Registered nurse	52	19.0
	Other	32	11.4
Length of employment	<6 months	36	13.2
	>6 months	237	86.8

Doctors, EMTs, District Health Visitors and Veterinarians had a higher average knowledge score compared to the other groups (see Figure 2).

A statistically significant difference in the mean knowledge score ($p = 0.027$) was noted for length of employment. Those working more than 6 months demonstrated higher mean knowledge scores than those employed <6 months. The ANONA ($p < 0.001$) suggested there was at least one mean knowledge score different for marital status. Upon investigation, there was very strong evidence ($p < 0.001$) of a difference between single persons compared to other groups. Thus, single participants had higher mean knowledge scores than the other groups. Similarly, there was evidence of a difference in the mean knowledge scores for income ($p < 0.001$), age ($p = 0.003$), category of staff ($p < 0.001$). The *post-hoc* test indicated this difference occurred between the groups earning <$5,000 and $20,001–$30,000. Participants earning <$5,000 had lower mean knowledge scores, whereas those earning $20,001–$30,000 had higher mean knowledge scores compared to the other categories. The age group 26–35 years and 36–45 years both had higher mean knowledge scores compared to the other groups whereas the age category 46–55 had lower mean knowledge scores compared to the other groups. Doctors had a higher mean knowledge score compared to the other groups.

Attitude toward the AstraZeneca vaccine

The mean attitude score toward the AstraZeneca vaccine was 2.63 (SD = 1.48) out of 5.83 (30.4%) participants had a good attitude score toward the AstraZeneca vaccine, 122 (44.7%) had a moderate attitude score and 68 (24.9%) had a poor attitude score. Using the Chi-square test, statistically significant associations were seen for attitudes and sex ($p = 0.01$), age ($p = 0.04$), marital status ($p = 0.009$), income level ($p < 0.001$), education level ($p = 0.005$) and category of staff ($p < 0.001$). These results are depicted in Table 2. 186 (68.1%) of the participants had good knowledge, 81 (29.7%) had moderate knowledge and 6 (2.2%) had a poor knowledge score.

Dentists had the highest mean attitude scores (see Figure 3). There was a statistically significant difference in the mean attitudes for length of employment ($p = 0.048$) and sex ($p = 0.031$). Those with more than 6 months service had better average attitude scores than those employed for <6 months. Also, males obtained better average attitude scores than females. The Kruskal-Wallis's test provided very strong evidence of a difference between the mean ranks of at least one pair of groups for marital status ($p = 0.026$), Income ($p < 0.001$), Education level ($p = 0.004$) and category of staff ($p < 0.001$). Upon investigation, there was very strong evidence ($p < 0.001$), single participants had significantly higher mean attitude scores than the other groups whereas participants in common law relationships had lower mean attitude scores. The income categories $15,001–$20,000 and $20,001–$30,000 had higher mean attitudes compared to the other groups whereas <$5,000 had a lower mean attitude score compared to the other groups. Tertiary level had higher mean attitude scores than the other Education categories. Doctors and Dentists had higher mean attitude scores than the other categories of staff.

Perception of the AstraZeneca vaccine

The mean perception score of the AstraZeneca vaccine was 38.19 (SD = 7.67) out of 45. 17 (6.2%) participants had a negative perception toward the AstraZeneca vaccine, 93 (34.1%) had a neutral perception and 163 (59.7%) had a positive perception. Using the Chi-square test, statistically significant associations were seen for perception and sex ($p = 0.002$), marital status ($p = 0.027$), income level ($p < 0.001$) and category of staff ($p < 0.001$) (see Table 2).

Doctors had the highest average perception score toward the AstraZeneca vaccine (see Figure 4). There was a statistically significant difference in the mean perception score for sex ($p = 0.001$) where males obtained better average perception scores than females. The Kruskal-Wallis's test provided very strong evidence of a difference between the mean ranks of at least one pair of groups for marital status ($p = 0.049$), Income ($p < 0.001$) and category of staff ($p < 0.001$). Upon investigation, there was very strong evidence

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TABLE 2 Participants score by categorization on KAP domains and Chi-square test of association results.

Variables	Knowledge			*p*-value	Attitude			*p*-value	Perception			*p*-value
	Good	Moderate	Poor		Good	Moderate	Poor		Negative	Neutral	Positive	
Sex												
Male	55	19	2	0.565	25	42	9	**0.01**	2	16	58	**0.002**
Female	131	62	4		58	80	59		15	77	105	
Age												
18–25	6	2	1	**0.042**	2	5	2	**0.04**	1	4	4	0.057
26–35	108	43	2		43	77	33		7	51	95	
36–45	38	15	1		17	22	15		2	18	34	
46–55	20	16	2		13	11	14		4	15	19	
56–65	13	5	0		7	7	4		3	5	10	
66 and up	1	0	0		1	0	0		0	0	1	
Marital status												
Married	80	26	0	**0.001**	37	38	31	**0.009**	7	37	62	**0.027**
Single	95	38	3		39	74	23		8	37	91	
Divorced	4	6	1		4	2	5		1	7	3	
Common law	6	8	1		1	7	7		0	10	5	
Widowed	1	3	1		2	1	2		1	2	2	
Income												
<$5,000	5	3	2	**0.001**	0	5	5	**<0.001**	1	6	3	**<0.001**
$5,001–$10,000	57	39	3		14	40	45		14	52	33	
$10,001–$15,000	27	12	0		16	14	9		1	14	24	
$15,001–$20,000	6	1	0		3	4	0		0	0	7	
$20,001–$30,000	85	22	1		49	53	6		0	19	89	
$30,001–$40,000	6	2	0		0	6	2		1	1	6	
>$40,000	0	2	0		1	0	1		0	1	1	
Education level												
Secondary level	17	9	1	**<0.001**	5	8	14	**0.005**	3	12	12	0.26
Trade school	0	0	1		0	0	1		0	1	0	
Tertiary level	169	72	4		78	114	53		14	80	151	
Category of staff												
Dentist	3	5	0	**0.016**	4	3	1	**<0.001**	0	2	6	**<0.001**
Dietician	1	3	0		0	1	3		0	4	0	
Doctor	96	23	1		50	62	8		0	20	100	
EMT	1	0	0		0	1	0		0	0	1	
ENA	12	12	1		3	6	16		6	15	4	
Other	22	9	0		10	12	9		3	10	18	
PCA	12	9	2		3	7	13		5	12	6	
Pharmacist	7	1	0		1	5	2		0	4	4	
Phlebotomist	0	1	0		0	0	1		0	1	0	
Registered nurse	32	18	2		12	25	15		3	25	24	
Length of employment												
<6 months	18	17	1	**0.041**	7	16	13	0.155	1	17	18	0.169
>6 months	168	64	5		76	106	55		16	76	145	

$p < 0.05$ is statistically significant. Statistically significant values are in bold.

($p < 0.001$) that single participants had significantly higher mean perception scores than the other groups. The income categories <$5,000 and $5,001–$10,000 had significantly lower mean perception scores than the other groups. Doctors and Dentists had higher mean attitude scores compared to the other categories of staff whereas Enrolled Nursing Assistants (ENAs) had lower mean perception scores compared to the other categories.

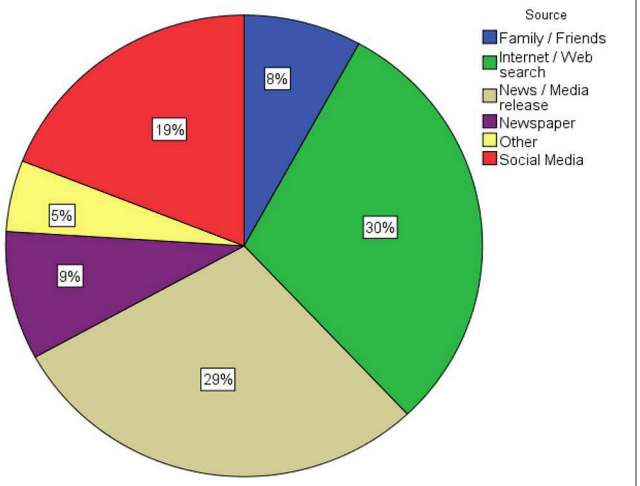

FIGURE 1
Participants' source of knowledge about the AstraZeneca vaccine.

The Chi-square test was used to assess any association between demographic features and categorized scores. Knowledge and Attitude were classified as good, fair, and poor whereas Perception was classified as positive, neutral, and poor (see Table 2).

Statistically significant associations were found between HCW's attitudes and perceptions toward the vaccine ($p < 0.001$) and ($p < 0.002$), respectively (see Table 3).

The top three reasons for not being vaccinated were, clinical trials being too short (27%), fear of adverse side effects (22%) and not enough information regarding vaccines (17%) (see Figure 5).

Discussion

Knowledge

A large portion of staff had good knowledge of the AstraZeneca vaccine. The mean knowledge score was 16.28 (out of 19 as total) with an overall correct response rate to each component of knowledge as 79%. With reference to a participant's knowledge on the AstraZeneca vaccine and their demographic features, many significant findings were discovered.

Single persons between the ages of 26–35 and 36–45, and those employed more than 6 months scored highest in the knowledge category. Furthermore, participants who received tertiary education, and those who made a monthly income more than $20,000TTD had significantly higher knowledge scores. In contrast, those earning a monthly income of <$5,000TTD and attaining only a secondary level education scored lowest in the knowledge domain. These findings

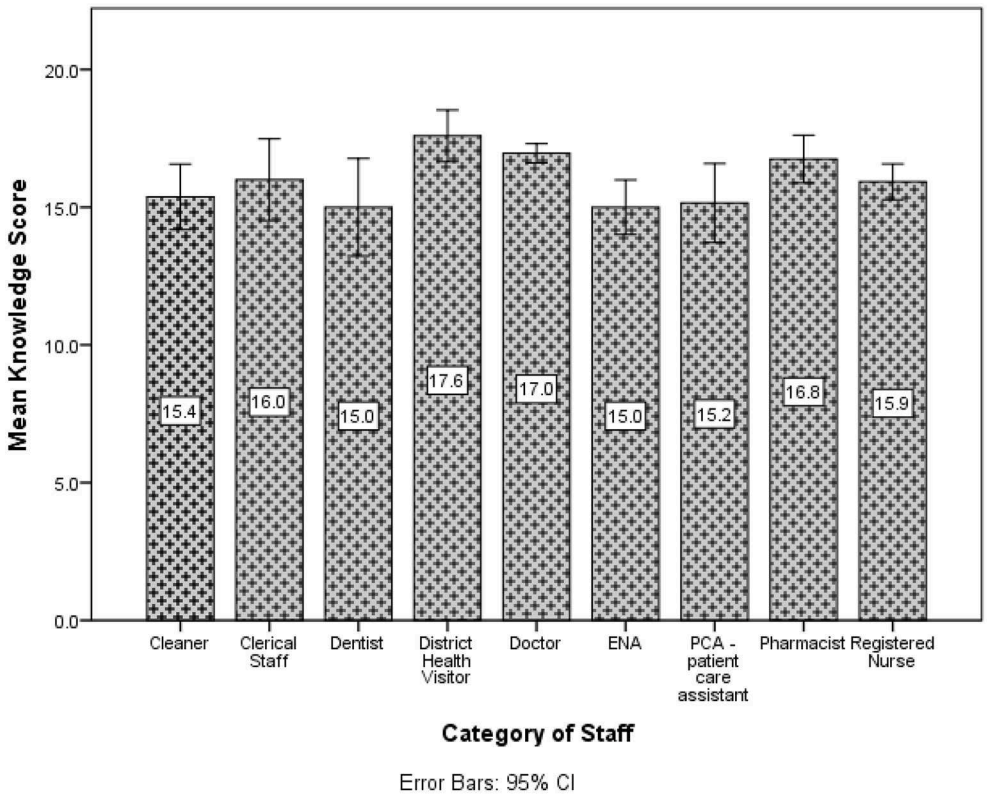

FIGURE 2
Participants' mean knowledge score about the AstraZeneca vaccine by category of staff.

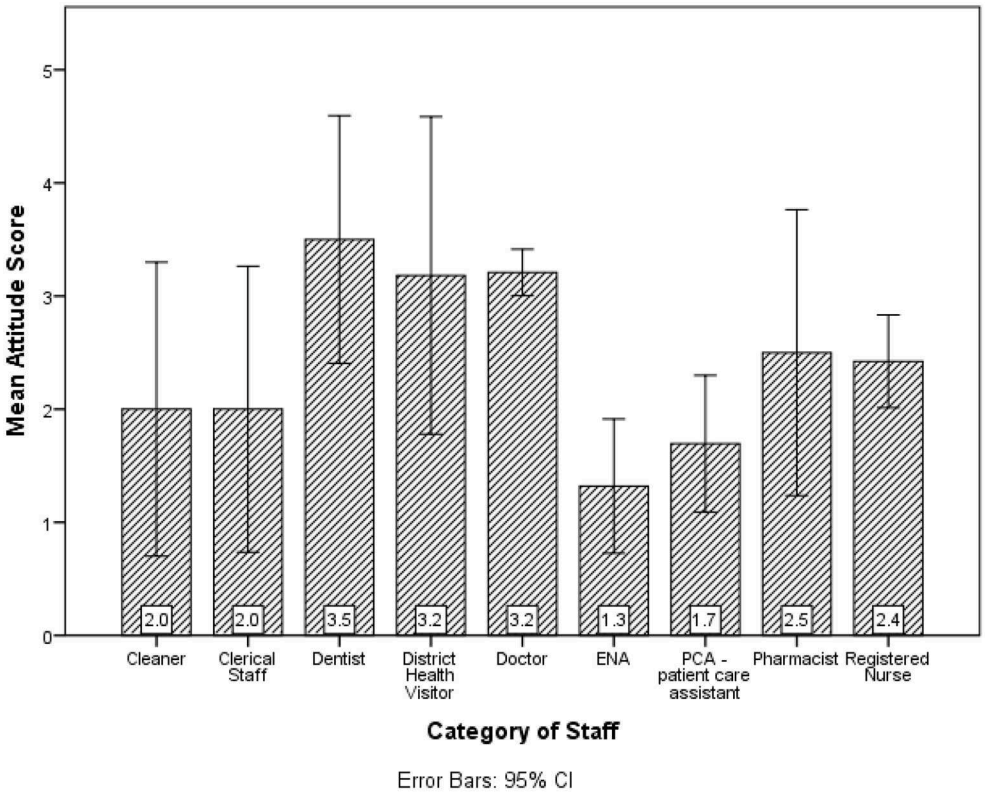

FIGURE 3
Participants' mean attitude score toward the AstraZeneca vaccine by category of staff.

are consistent with Islam et al. which showed that participants with higher levels of education and higher socio-economic statuses were more knowledgeable about COVID-19 vaccines (11). Albahri et al. demonstrated that those with higher educational backgrounds and those interested in their health and wellbeing tend to be more knowledgeable on health-based topics (12).

In this study doctors obtained the highest average mean knowledge score compared to other professions. This finding is supported by Mirowsky et al. (13) and Limbu et al. (14) which also reported higher knowledge scores for doctors compared to other HCW's. This is expected as doctors tend to engage in more rigorous research to augment their professional capabilities and may also be more likely to have access to clinical databases and resources (10).

There were significant differences in knowledge amongst various domains; be it age, occupation, marital status, socioeconomic status, or length of employment. It is important however for clinical staff to have minimum baseline levels of knowledge. That way the likelihood of accurate information being disseminated to the public is higher. This is especially important as previous research has documented that the most trusted source of information about the COVID-19 vaccine are from members of the health sector, inclusive of health care workers and the health ministry (5, 12).

In this study the most frequently cited source of information on the COVID-19 vaccine for staff was the internet (30%), followed closely by news or media releases (29%). Indeed, social media is recognized as a significant source of information about the COVID-19 vaccine amongst multiple populations (15, 16). Social media is also thought to provide an overabundance of information which tends to lead to fear and panic and it has also been shown to spread a vast amount of misinformation and contribute significantly to conspiracy theories (17) which concluded that social media would have contributed to a poorer knowledge score.

Attitudes and perceptions

There were many associations found between demographics and both attitude and perception. Statistically significant associations were found between HCW's attitudes and perceptions toward the vaccine. This is expected as both are contributors to vaccine acceptance. Significant associations were also found between knowledge, attitudes, and perceptions, where they were directly proportional to each other.

Most participants had a moderate to good attitude and a positive perception about the AstraZeneca COVID-19 vaccine. Having a positive attitude and perception was associated with being single, longer lengths of employment, higher incomes, higher education levels and being a medical professional.

Single healthcare workers were more knowledgeable about the COVID-19 vaccine and had higher mean attitude and perception scores. This may be due to the fact that single persons are thought to be more career driven and have more time at their disposal, devoid of domestic commitments (18). Therefore, such persons may be more likely to perform research and stay up to date with current guidelines and recommendations.

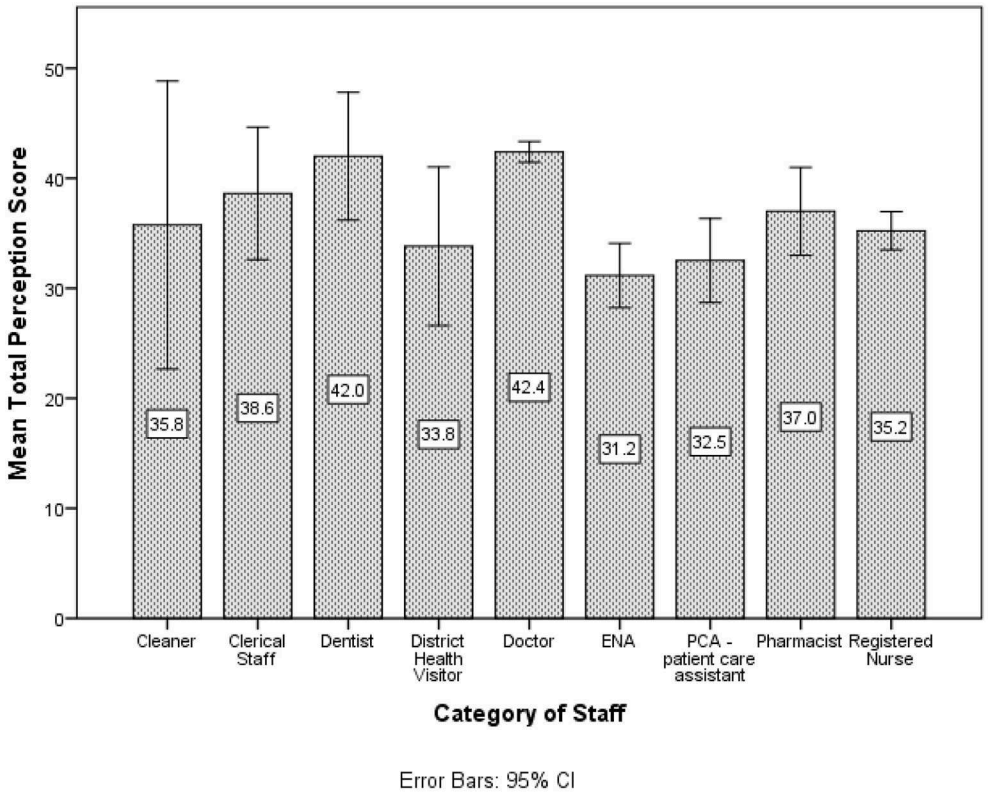

FIGURE 4
Participants' mean perception score toward the AstraZeneca vaccine by category of staff.

No significant associations were found between HCWs age and attitudes or perceptions about the AstraZeneca vaccine. This is at variance with other research findings which demonstrated that older individuals may be more willing to receive a vaccine as they possessed medical experience and perceived COVID-19 as a greater risk (19). In this study, however, it is noteworthy that respondents with a longer length of employment had a better perception of the AstraZeneca vaccine.

Healthcare workers with a lower education level displayed more vaccine hesitancy. Possible reasons for this finding include being less updated on new research, less awareness of the COVID-19 vaccine, greater likelihood of belief in community myths and less concerns of possible risks associated with the COVID-19 virus (19).

Doctors and dentists had the highest mean attitudes and perception scores about the AstraZeneca vaccine. This was in keeping with their higher mean knowledge scores. In addition, attitudes and perceptions were positively correlated to knowledge scores.

A positive association was found between sex, attitudes, and perceptions of the AstraZeneca vaccine. Males had better mean attitude and perception scores compared to females. This finding is consistent with other studies (20, 21). Women are more likely to question the safety, efficacy and quality of the COVID-19 vaccine thereby leading to vaccine hesitancy (22, 23). Vaccine novelty may also help explain this finding. Indeed, newness of the vaccine and a fear of possible adverse effects have been attributed to vaccine hesitancy amongst women (22). Women comprise a large portion of the healthcare workforce. With an increased workload due to the pandemic, they still must balance other responsibilities and if there was an adverse event, they may be unable to perform their abundance of duties (23, 24). It is possible therefore, that the magnitude of the demands on women compounded by the stresses of their jobs contributed to their less favorable attitudes and perceptions to the vaccine (25).

Another factor that is known to contribute to vaccine hesitancy in females is the unknown effects on fertility, pregnancy, and breastfeeding. The COVID-19 virus can have many adverse effects on both mother and fetus. These include preterm labor, pregnancy loss, Intensive Care Unit (ICU) stay and death (24, 26). WHO has since recommended the need for vaccination amongst these populations. Vaccine hesitancy amongst females has also been attributed to misinformation of the effect of COVID-19 on fertility but this is yet to be proven (26).

Recommendations

Our study revealed that the main contributors to vaccine hesitancy were inadequate duration of clinical trials and fear of adverse side effects. There was also a significant number of participants (17%) who were unwilling to get the vaccine due to lack of information. There are many different strategies that can be used to combat these factors and help in encouraging vaccination.

Greater wide-scale use, and since one of the more prominent and trusted sources of information about the vaccine in this study was news/media releases, informative sessions disseminated *via* the media would likely be beneficial. Infomercials *via* the radio and

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TABLE 3 Mean scores with respect to demographics and *p* values (independent samples *t*-test for two categories, ANOVA for more than 2).

Variables	Knowledge		Attitude		Perception	
	Mean (SD)	*p*-value	Mean (SD)	*p*-value	Mean (SD)	*p*-value
Sex*						
Female	16.21 (2.17)	0.812	2.51 (1.54)	**<0.001**	37.22 (790)	**0.002**
Male	16.41 (2.54)		2.93 (1.25)		40.72 (6.41)	
Age**						
18–25	15.22 (3.56)	**0.03**	2.44 (1.51)	0.561	35.89 (7.31)	0.197
26–35	16.55 (2.16)		2.67 (1.34)		38.81 (6.91)	
36–45	16.52 (1.81)		2.59 (1.51)		38.76 (8.52)	
46–55	15.00 (2.67)		2.42 (1.77)		36.32 (8.76)	
56–65	16.31 (2.00)		2.83 (1.82)		35.89 (8.37)	
66 and up	18.50 (0.00)		5.00 (0.00)		47.00 (0.00)	
Marital status**						
Common-law marriage	15.00 (3.57)	**<0.001**	1.53 (1.25)	**0.015**	35.27(6.01)	0.074
Divorced	13.41 (3.23)		2.09 (1.76)		34.00 (8.75)	
Married	16.68 (1.71)		2.67 (1.56)		37.92 (7.84)	
Single	16.43 (2.13)		2.79 (1.34)		39.17 (7.41)	
Widowed	13.70 (3.15)		2.00 (2.00)		35.40 (9.45)	
Income TTD**						
<$5,000	13.80 (4.61)	**<0.001**	1.50 (1.27)	**<0.001**	34.10 (8.06)	**<0.001**
$5,001–$10,000	15.76 (2.23)		1.87 (1.43)		33.78 (7.58)	
$10,001–$15,000	16.45 (2.04)		2.97 (1.68)		37.69 (7.25)	
$15,001–$20,000	16.93 (1.92)		3.57 (0.79)		43.14 (3.76)	
$20,001–$30,000	16.90 (1.91)		3.29 (1.09)		42.40 (4.98)	
$30,001–$40,000	16.25 (1.95)		2.25 (0.89)		40.00 (9.12)	
>$40,000	15.00 (0.71)		2.00 (2.83)		35.50 (14.85)	
Education level**						
Secondary level	15.69 (2.84)	**0.004**	1.85 (1.43)	**0.003**	35.22 (8.68)	**0.04**
Tertiary level	16.37 (2.17)		2.73 (1.45)		38.56 (7.48)	
Trade school	9.50 (0.00)		0.00 (0.00)		28.00 (0.00)	
Category of staff**						
Dentist	15.00 (2.12)	**<0.001**	3.50 (1.31)	**<0.001**	42.00 (6.95)	**<0.001**
Dietician	14.75 (1.50)		0.75 (0.96)		31.00 (5.35)	
Doctor	16.96 (1.93)		3.21 (1.14)		42.39 (5.23)	
EMT	17.00 (0.00)		2.00 (0.00)		42.00 (0.00)	
ENA	15.00 (2.41)		1.32 (1.44)		31.16 (7.08)	
Other	16.50 (1.85)		2.61 (1.61)		37.35 (8.51)	
PCA—patient care assistant	15.15 (3.32)		1.70 (1.40)		32.52 (8.85)	
Pharmacist	16.75 (1.04)		2.50 (1.51)		37.00 (4.78)	
Phlebotomist	15.50 (0.00)		1.00 (0.00)		25.00 (0.00)	
Registered nurse	15.62 (2.34)		2.42 (1.47)		35.23 (6.208)	
Length of employment*						
<6 months	15.61 (2.27)	0.085	2.17 (1.48)	**0.06**	36.94 (6.97)	0.49
>6 months	16.38 (2.27)		2.70 (1.47)		38.38 (7.76)	

$p < 0.05$ is statistically significant. *Independent samples t-test. **ANOVA. Statistically significant values are in bold.

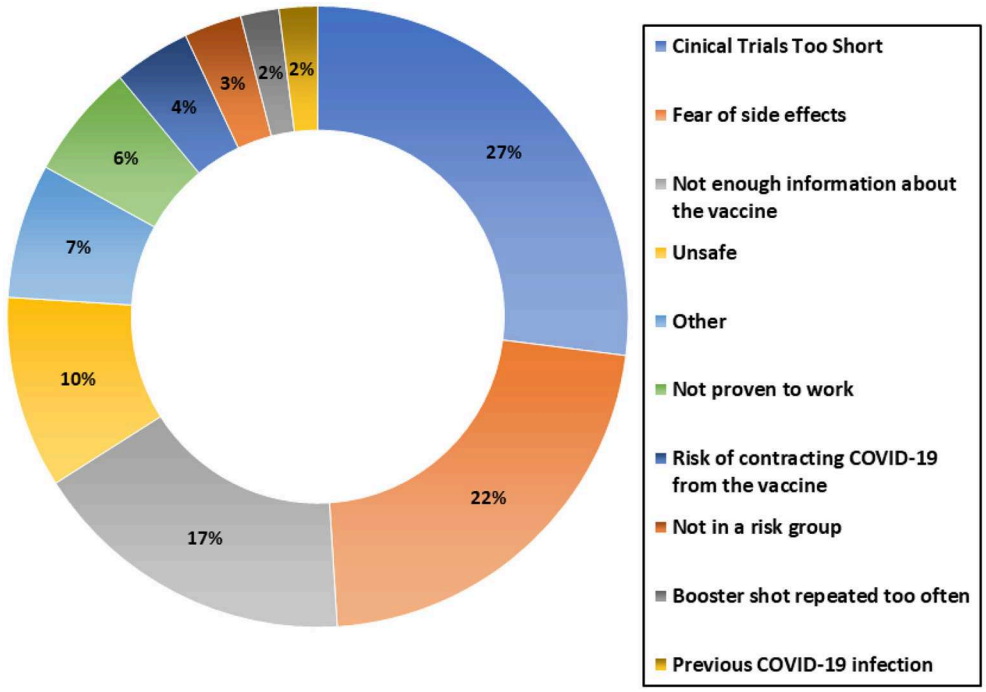

FIGURE 5
Reasons for not being vaccinated.

television with a view to educating the public on vaccine availability and accessibility and highlighting common side effects that can be expected will also assist. Messages can be reinforced by qualified physicians using question-and-answer segments which will assist in promoting accurate information and correcting misinformation.

The following are recommended strategies to promote workplace and community vaccination. Firstly, to be able to get this information to the intended audience, seminars or meetings can be organized which aim to educate and encourage vaccination. These can be online seminars to avoid in-person interactions during this pandemic. Small group sessions of ~10 persons are recommended so that individuals feel comfortable to speak openly and ask questions. These sessions can be led by primary care doctors, or medical experts and can include varying categories of clinical staff per session.

These meetings should follow a general format whereby potential benefits of the vaccine can be discussed, and vaccine confidence enhanced. The aim is to educate by firstly giving key facts on the vaccine, debunking myths, and answering the frequently asked questions inclusive of vaccine exemption eligibility. These meetings can also include other HCWs who have been vaccinated and those who have personal experiences with the COVID-19 virus, who can emphasize the seriousness of the disease, its complications, and the importance of being vaccinated.

Post-seminar, physicians can be made available for the purposes of health promotion and sensitization. Those who are afraid to get vaccinated or believe they should have an exemption but do not fit the criteria can be offered a general check-up to ensure that it is safe for them to take the vaccine and perhaps increase their willingness to receive vaccination.

Another factor that is known to help encourage vaccination is to provide incentives or benefits to vaccinated workers (27). For those who opt to get vaccinated, time off from work can be granted for recovery from possible side effects. Accessories such as vaccination card holders and stickers can also be made available at no cost to further enhance uptake. Confirming appointments in advance for vaccination can assist in reducing wait-times and enhancing the efficiency of the vaccination process. Social media and networks can be utilized to issue reminders for appointments and provide additional information and updates regarding vaccine accessibility and availability.

Our study provides novel findings related to Health Care workers receptivity toward vaccination in our country in the context of a pandemic. It is envisaged that these findings will augur well for pandemic preparedness and response going forward.

Limitations

The study population was limited to Primary Health care workers in North Central, Trinidad. Ideally, to acquire a national representation of a health care worker's knowledge, attitudes and perceptions toward the AstraZeneca vaccine, the study population should incorporate all the regions within Trinidad and Tobago. Additionally, such a study should be expanded to include staff at Primary, Secondary and Tertiary health care facilities. A follow up study would therefore be encouraged to determine whether the inferences drawn in this study apply nationwide.

Also at the time this study was conducted, the AstraZeneca vaccine was the only vaccine available in Trinidad and Tobago. Ideally, future research should incorporate all brands of COVID-19 vaccines available in Trinidad and Tobago to enable a more accurate

representation of the knowledge, attitude, and perceptions toward the COVID-19 vaccine amongst healthcare workers.

It is acknowledged that effect sizes could not be computed due to the nature of the analyses performed and that this study is underpowered as the calculated sample size of 384 was not attained. This limits the generalizability of our findings.

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 North Central Regional Health Authority. The patients/participants provided their written informed consent to participate in this study.

Author contributions

RK conceived and designed the study and wrote the paper. RB performed the data analysis. RA, LA, RD, TF, TH, AK, KM, RM, CP, and AR collected data and conceived and designed the analysis. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2023.1094001/full#supplementary-material

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The impact of COVID-19 certification mandates on the number of cases of and hospitalizations with COVID-19 in the UK: A difference-in-differences analysis

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Background: Mandatory COVID-19 certification, showing proof of vaccination, negative test, or recent infection to access to public venues, was introduced at different times in the four countries of the UK. We aim to study its effects on the incidence of cases and hospital admissions.

Methods: We performed Negative binomial segmented regression and ARIMA analyses for four countries (England, Northern Ireland, Scotland and Wales), and fitted Difference-in-Differences models to compare the latter three to England, as a negative control group, since it was the last country where COVID-19 certification was introduced. The main outcome was the weekly averaged incidence of COVID-19 cases and hospital admissions.

Results: COVID-19 certification led to a decrease in the incidence of cases and hospital admissions in Northern Ireland, as well as in Wales during the second half of November. The same was seen for hospital admissions in Wales and Scotland during October. In Wales the incidence rate of cases in October already had a decreasing tendency, as well as in England, hence a particular impact of COVID-19 certification was less obvious. Method assumptions for the Difference-in-Differences analysis did not hold for Scotland. Additional NBSR and ARIMA models suggest similar results, while also accounting for correlation in the latter. The assessment of the effect in England itself leads one to believe that this intervention might not be strong enough for the Omicron variant, which was prevalent at the time of introduction of COVID-19 certification in the country.

Conclusions: Mandatory COVID-19 certification reduced COVID-19 transmission and hospitalizations when Delta predominated in the UK, but lost efficacy when Omicron became the most common variant.

KEYWORDS

covid certificate, covid passport, real-world data, observational studies, public health

Introduction

More than a year after the emergence of SARS-CoV-2, widespread transmission is arguably higher than ever. To date, 30th of January 2023, the virus has caused more than 22,200,000 confirmed cases, 990,000 hospital admissions and 217,000 deaths in the UK (1). All around western countries there has been a need to balance restrictions to fight the pandemic while controlling their impact on society.

The Delta variant of the virus became dominant soon after its arrival to the UK in the spring of 2021. The following November the UK reported the first confirmed cases of the Omicron variant. The UK Health Security Agency estimated the current prevalence of Omicron to be higher than 90% as of end-January, having quickly overcome Delta as the most common variant (2).

Since the emergence of the virus, various non-pharmaceutical interventions were introduced by several countries in Europe to fight against the COVID-19 pandemic. Their aim was to slow down the transmission by restricting mobility and social interactions, e.g., mass gathering measures. Several papers suggest some of them had an effect in reducing COVID-19 transmission (3–5). Recently, mandatory COVID-19 certification regulating access to public venues, nightclubs or cultural events was implemented in some countries, using proof of at least two doses of an approved vaccine, negative test (usually within the last 2 days) or a recovery certificate of a recent infection (usually within the previous 6 months) (6). Many voices have expressed concerns over its effectiveness and due to their potentially negative effects on the economy, for example in the hospitality sector. Some studies report increased vaccine uptake after its implementation (7, 8), but there is a lack of research on its potential impact in reducing incidence of COVID-19. It is possible the certification influenced the spread of the virus directly by restricting contact between individuals, or through acceleration of vaccination in the population.

The UK implemented COVID-19 certification during the second half of 2021, and each of its countries did it at different times. The certificate became mandatory to attend large events and nightclubs in October 2021 in Wales and Scotland, and in December 2021 in England. In addition to these events, a mandatory certificate also restricting access to cinemas, theaters and concert halls was implemented in November in Wales and Northern Ireland. More information on the application of the COVID-19 certificate in the different countries can be found in the *Methods* section. We took advantage of this natural experiment to study whether COVID-19 certification in the UK had an effect in reducing the incidence of COVID-19 cases and hospitalizations, considering the four countries separately. We use England as a negative control, since it was the last country where COVID-19 certification was introduced.

Methods

Data

Data on COVID-19 cases and hospital admissions in the UK was gathered from the UK Coronavirus Dashboard (1), which is updated every day. Data on the implementation of the COVID-19 certification in Scotland, England, Northern Ireland and Wales was collected from official sources, as mentioned in media (9–12). For all sources, we used data from the 1st of January 2021 to the 19th of January 2022. Data was extracted on the 19th of January 2022. Data from mid-year 2021 population for each country was extracted from the UK Coronavirus Dashboard (1) as well.

COVID-19 certification

We studied the four countries of the UK (England, Scotland, Northern Ireland and Wales). A country was considered as implementing COVID-19 certification (CC) if the certificate was required for at least some frequently used public venues such as restaurants, nightclubs or cultural events. Scotland implemented COVID-19 certification on the 18th of October, Northern Ireland did it on the 29th of November. In the case of Wales, we modeled two different changes in the restriction of the certificate, as COVID-19 certification was first implemented for nightclubs on the 11th of October 2021 and then extended to cinemas, theaters and concert halls on the 15th of November 2021. England was the last country to require the certificate, only doing so after the 15th of December. See Table 1 for further detail on each country's implementation of the COVID-19 certification.

Outcomes

We studied two outcomes, for which we assessed the effect of the COVID-19 certification intervention: incidence rate of COVID-19 confirmed cases and incidence rate of COVID-19 hospital admissions in the general population. We introduced a lag after it to neglect data right after the intervention date, for which its effects were not expected to be significant. The lag was set to 5 days for COVID-19 cases and to 7 days for COVID-19 hospital admissions (13, 14).

Study time intervals

We selected the time intervals for the study of each intervention as wide as possible, provided that they did not include more than one change in the intervention, that they included more than 10 points (days) at each side of the lag interval and that they did not show, if possible, exogenous changes in convexity.

Models

We performed Negative binomial segmented regression (NB) and Autoregressive integrated moving average (ARIMA) models as a preliminary and sensitivity analysis of the main model, Difference-in-Differences. Detailed methods results and output for NB and ARIMA can be found in the Supplementary material.

Difference-in-Differences (DiD) methods compare the mean of the variable of interest for an exposed and control group, before

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TABLE 1 Information on COVID-19 certification in all the countries of the UK.

Region and intervention	Wales CC1	Wales CC2	Scotland CC1	Northern Ireland CC1	England CC1
Intervention date	11/10/2021	15/11/2021	18/10/2021	29/11/2021	15/12/2021
Restrictions imposed	COVID-19 certificates—including either vaccination status or a negative COVID-19 test within the past 48 h—have been required to attend nightclubs, unseated indoor events with over 500 people, unseated outdoor events with over 4,000 people, and any event with over 10,000 people.	Extended to cinemas, theaters and concert halls.	COVID-19 certificates have been required to attend nightclubs, unseated indoor events with over 500 people, unseated outdoor events with over 4,000 people, and any event with over 10,000 people.	The pass would be mandatory in the same venues as Wales and also pubs and restaurants.	COVID-19 certificate will now be mandatory for nightclubs, unseated indoor events with 500 or more attendees, unseated outdoor events with 4,000 or more attendees and any event with 10,000 or more attendees.

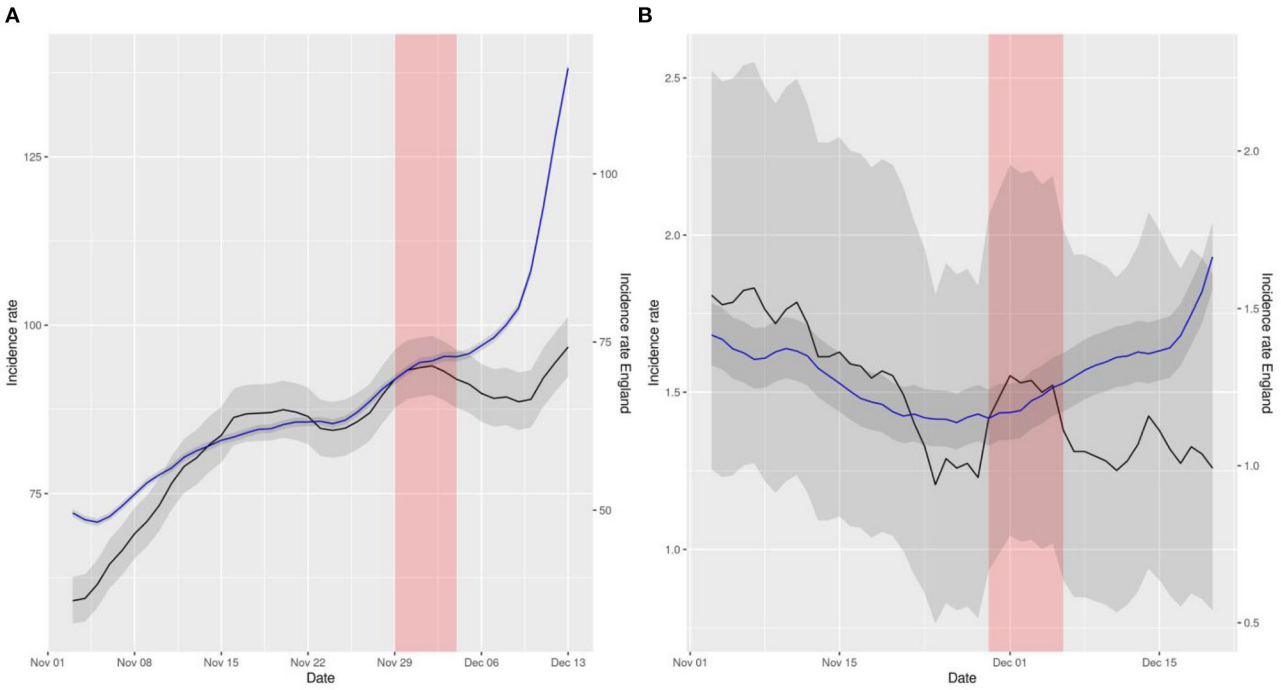

FIGURE 1
Representation of smoothed daily incidence rates of cases **(A)** and hospital admissions **(B)** in Northern Ireland (data in black) vs. England (data in blue) per 10^5 inhabitants. Data has been displaced so that both curves intersect right at the intervention time point. The red shaded area represents the neglected period post-intervention in the model due to the lag between the intervention and its effect and the gray shaded area represents the 95% confidence intervals of the calculation of incidence rates.

and after a certain interruption point, providing insight on the changes of the variable for the exposed countries relative to the change in the negative outcome group (15). We cannot draw causal conclusions by simply observing before-and-after changes in outcomes, because other factors might influence the outcome over time. DiD methods overcome this by introducing a comparison between two similar groups exposed to different conditions. First, DiD takes the difference of the variable of interest of both groups before and after the intervention. Then it subtracts the difference of the control group to the difference of the exposed one to control for time varying factors, therefore giving a result which constitutes a difference of the differences. This approximates the clean impact of the intervention. In essence, the DiD estimating equation is the following,

$$Y_{gt} = \beta_0 + \beta_1 T_g + \beta_2 P_t + \beta_3 \left(T_g x P_t\right) + \epsilon_{gt}$$

where Y_{gt} is the outcome for an individual in group g and treated unit t, P_t is a binary time variable indicating whether the observation belongs to the period before or after the intervention and T_g is a binary variable indicating whether the observation belongs to the exposed or the controlled group. In this setting,

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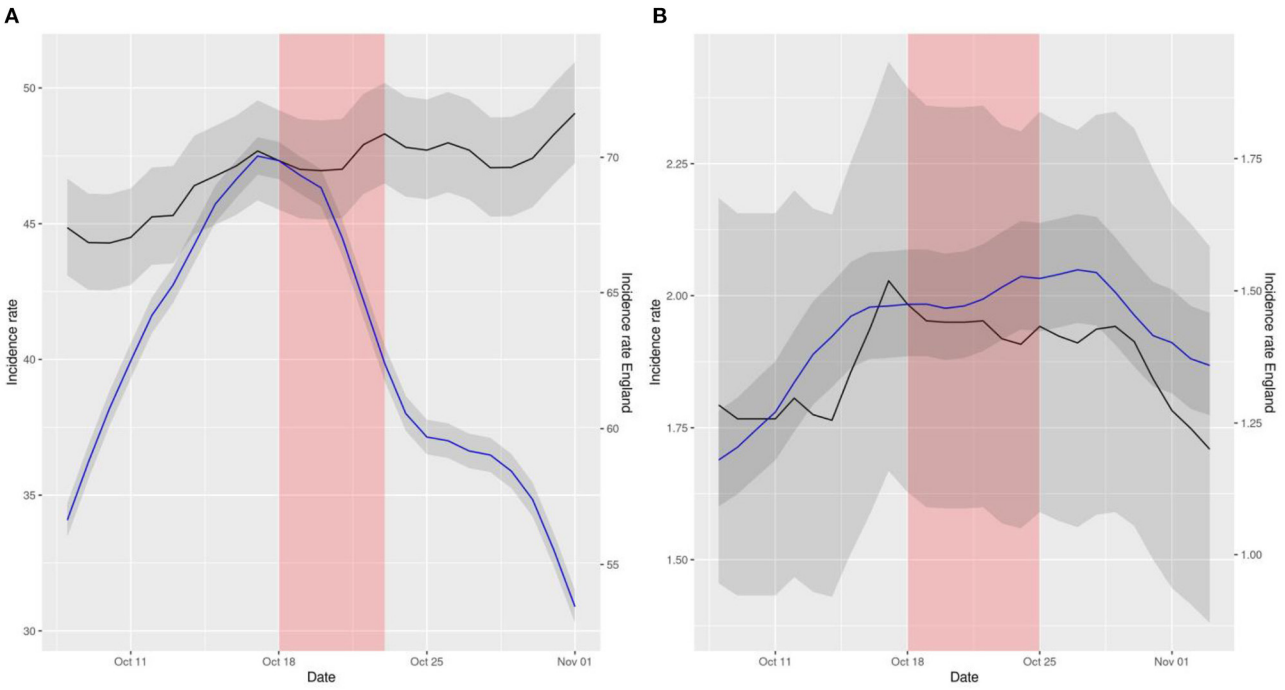

FIGURE 2
Representation of smoothed daily incidence rates of cases **(A)** and hospital admissions **(B)** in Scotland (data in black) vs. England (data in blue) per 10^5 inhabitants. Data has been displaced so that both curves intersect right at the intervention time point. The red shaded area represents the neglected period post-intervention in the model due to the lag between the intervention and its effect and the gray shaded area represents the 95% confidence intervals of the calculation of incidence rates.

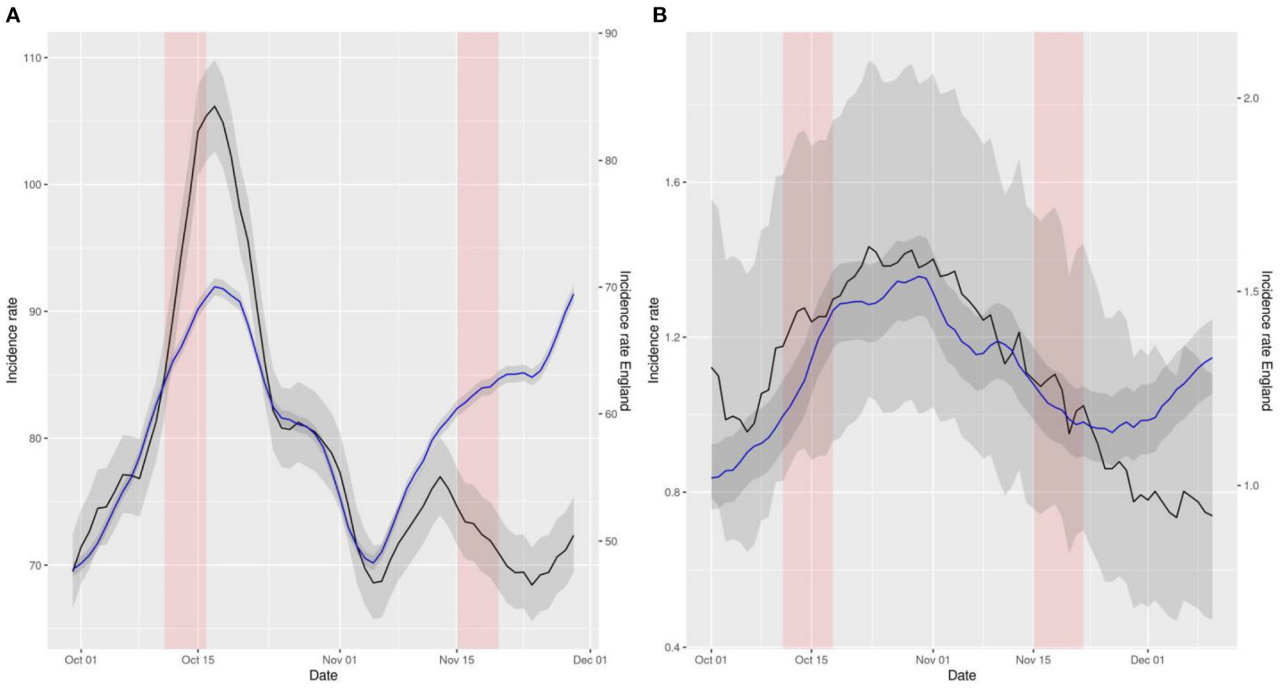

FIGURE 3
Representation of smoothed daily incidence rates of cases **(A)** and hospital admissions **(B)** in Wales (data in black) vs. England (data in blue) per 10^5 inhabitants. Data has been displaced so that both curves intersect right at the intervention time point. The red shaded area represents the neglected period post-intervention in the model due to the lag between the intervention and its effect and the gray shaded area represents the 95% confidence intervals of the calculation of incidence rates.

TABLE 2 Estimates and 95% confidence intervals of the effect of the COVID-19 certification in the DiD models for the different countries and outcomes.

	Wales CC1	Wales CC2	Northern Ireland CC1	Scotland CC1
Cases IR estimate	2.2	−7.75	−10.1	7.91
95% CI cases	(−6.24,10.7)	(−13.1, −2.46)	(−18.4, −1.79)	(4.46, 11.4)
Admissions IR estimate	−0.144	−0.169	−0.269	−0.097
95% CI admissions	(−0.248, −0.039)	(−0.308, −0.031)	(−0.385, −0.153)	(−0.219, 0.024)

The numbers represent incidence rates per 1,00,000 people.

the treatment effect is estimated with the coefficient β_3 from the regression.

For this method to be rightly used, all the typical OLS assumptions must be met. The parallel trends assumption, which requires both groups to present similar trends before the intervention time point (16), must also be satisfied. We tested all these assumptions, and the latter can be visually inspected in Figures 1–3.

DiD models produce estimates which consider a counterfactual group, therefore adjusting for unmeasured confounding. This cannot be done by neither of the two previous models. Its biggest limitation is that, in the end, the measured effect can only be attributed to the timepoint chosen. If that is due to the intervention placed then, or to other underlying reasons around the same time, cannot be known by design.

Statistical analysis

We calculated incidence rates as number of cases (COVID-19 or admissions) divided by each country's population. We also calculated 7-day smoothed rolling average rates to reduce the effects of lower reporting on weekends.

We performed the first analysis on the 7-day smoothed data using NBSR. We also considered ARIMA models for autocorrelation.

To further strengthen the results and given that England did not implement the COVID-19 certification when it was effective in the other three countries, we used its data as a counterfactual for Difference-in-Differences (DiD) models. To help visualize this method, a plot of the difference and cumulative difference of the incidence rates for cases and hospitalizations of all countries is provided in Supplementary Figure 5. The numbers shown are essentially what constitute the basis of the DiD model. The differences have been calculated extracting England's incidence rates from the other countries' incidence rates. A decreasing trend in the difference's plots (on the left) is associated with a protective effect of the intervention date on the outcome.

We performed all the analyses in R v4.3 and used the packages epiR, tidyverse, forecast, ggplot2, MASS and lmtest. Code is available in https://github.com/KimLopezGuell/Covid-passport.

Results

Table 2 contains results of a DiD regression for both cases and admissions incidence rates of the different UK countries (Wales, Northern Ireland, Scotland) compared to England. Except from cases in Scotland and cases in the first intervention in Wales, all the other COVID-19 certification introductions appeared to be effective against the spreading of the virus. Note the significance of the coefficients, in the sense that their 95% confidence interval does not include any positive subinterval.

The reported coefficient of the DiD model is β_3, which is the one we are most interested in. It is understood as how much the average outcome of the treatment group has changed in the period after the intervention, compared to what it would have happened to the same group had the intervention not occurred. Taking Wales CC1 admissions, −0.144 95% (95% CI −0.248, −0.039), this means that the incidence rate per 100,000 people was 0.144 units smaller on average in Wales after (and because of) the intervention.

The first COVID-19 certification introduction in Wales was not seen effective in terms of reduction on the number of cases, compared to England, with an associated coefficient of 2.22 (95% CI −6.24,10.7). It was associated, however, with a reduction of admissions, with a coefficient of−0.144 (95% CI −0.248,−0.039). In November, the increased restriction of the COVID-19 certification led to a decrease in the incidence rates of both outcomes compared to England, with coefficients −7.75 (95% CI −13.1, −2.46) for incidence rate of cases and −0.169 (95% CI −0.308, −0.031) for incidence rate of hospital admissions.

Northern Ireland showed a similar result, with coefficients −10.1 (95% CI −18.4, −1.79) and −0.269 (95% CI −0.385, −0.153) for incidence rates of cases and hospital admissions respectively.

As for the number of cases in Scotland, there also seemed not to be an effect of the COVID-19 certification, with a coefficient of 7.91 (95% CI 4.46, 11.4). Nonetheless the method indicated a significant effect on the incidence rate of hospital admissions, with a DiD coefficient of −0.097 (95% CI −0.219, 0.024).

The aforementioned comparisons can be visually inspected in Figures 1–3. These figures represent the incidence rates calculated using the raw data of COVID-19 outcomes and baseline numbers of population in all the countries taken from the COVID Dashboard (1). The 95% confidence intervals were calculated assuming that the data were distributed according to a Poisson distribution, which is common practice (17). The plots have been displaced, in the sense that each line has its own y axis, to allow the reader to test the linear trend assumption in DiD better.

NBSR and ARIMA models (Supplementary material) support these findings.

Discussion

Using NBSR modeling, we found COVID-19 certification interventions were associated with a decrease in the incidence

of COVID-19 cases in all countries except England, and with a decrease in COVID-19 hospitalizations only in Scotland. ARIMA models, which control for autocorrelation of the observations, supported these findings. DiD analyses supported a causal effect of CCs to decrease incidence rates in most territories, using England as a counterfactual. However, the study of COVID-19 certification intervention in England itself on the 15th of December 2021 shows that it was insufficient to prevent the increase in either the incidence of cases or hospital admissions in the country.

This discrepancy between the effect of COVID-19 passports in England compared to the other countries might be due to the new Omicron variant of the virus [which represented the 75% of the population of the country by that date (18)], the effect of other coexistent measures (like the mandatory use of face masks or accelerated booster vaccine campaign) or the already high uptake in vaccination. Indeed, as of 12th December 2021, almost 9 in 10 individuals aged 12 and over had been vaccinated with at least one dose (42,561,679, 88.0%), more than 8 in 10 individuals aged 18 and over had been vaccinated with both doses (38,627,544, 86.9%) and more than 6 in 10 individuals aged 40 and over had received a booster or 3rd dose (18,128,105, 63.8%) (19).

The visual difference in the NBSR plots, with England as a negative control group, reinforced the previous conclusions. Plots depicting the situation in Wales, for instance, suggested a striking effect compared to England. The intervention was not associated with a reduction of hospitalizations for some countries, but even in those cases, comparing to England, the plots indicated an impact of COVID-19 certification on reducing the increasing trend of hospital admissions observed at the same time in the English NHS.

In the DiD analyses, we found a significant effect of COVID-19 certification interventions for both incidence rates of cases and hospital admissions in Northern Ireland and the second half of November in Wales, compared to England, where the restriction was not into effect. The impact was not significant for the incidence rate of cases in Scotland nor October in Wales (first CC intervention), yet it was for hospital admissions. In fact, during that period the number of cases did decrease abruptly in Wales after the introduction of the COVID-19 certification. However, as they also decreased in England, the intervention effect was not so obvious. As for Scotland, the difference in trends pre-intervention for both groups is too acute to be able to interpret this model in a sensible way, as the assumptions for its validity are surely violated. In that sense, the DiD plots provided in the results section for all regions and outcomes, compared to England, in which both trends have been superposed to better see its similarities and differences, serve as a check for the validity of this assumption. We note, as commented before, that this condition is arguably satisfied for all pairs except for cases in Scotland. Hence, we can conclude that the reported effects of the certification as an intervention that reduced the incidence of COVID-19 are reliable.

These results are coherent with previous reported increased vaccine uptake after COVID-19 certification implementation (7, 8). Indeed, apart from the obvious restriction of mobility, the introduction of the COVID-19 certification and a subsequent increase in vaccine uptake could account for a lowering in both incidence of COVID-19 cases and hospitalizations. Moreover, this would explain the inefficiency observed in controlling the Omicron variant, as recent studies have reported lower effectiveness of the vaccines against infection by this variant (20–22). Indeed, these suggest that the Omicron variant can evade the immune protection conferred by vaccines, thus limiting their effectiveness to minimize the risk of infection.

Limitations of our analyses include the aggregated nature of our data, therefore potentially limited by ecological fallacy. Time varying influential factors have possibly been controlled with DiD methods taking England as a negative control group, yet other differences between the regions might be prevalent and affect the spreading of the virus differently. Moreover, the interventions were introduced at different times and with different limitations, and the response of the population to them might have been different in different regions. An unquestionably fair comparison is thus impossible.

On another note, an anticipatory effect of the certification could also be possible and has not been accounted for. Individuals might have pre-emptively reacted to the intervention, therefore pushing any potential consequences earlier in time. If so, accounting for a certain lag before the intervention date could be reasonable. This sensitivity analysis was not done in this study, and available data does not seem to indicate this should be of concern to our analyses.

It is important to stress that we cannot assert with undeniable confidence that these effects are due to COVID-19 certification, for a variety of reasons, stated throughout this paper. Mainly, we cannot disentangle effects of other contemporary measures from the effect of COVID-19 certification with this model. It is likely this intervention is linked to an increase in vaccination uptake, which is related to a change in the studied outcomes. Mandatory COVID-19 certification might be therefore a good measure for governments to implement, together with other measures, especially in areas with less vaccine coverage. It could be effective in limited periods of time and populations to boost vaccination. However, it cannot substitute a universal vaccination campaign with specific public health interventions to ensure equitable access to vaccines.

In conclusion, we demonstrate that the introduction of mandatory certificates was effective in decreasing cases in all countries except in England. This could be explained by differences of concomitant measures, on baseline vaccination uptake or by the emergence of the Omicron variant. Mandatory certification is only one of many policy levers to control the pandemic, and a sensible reassessment of its efficacy should be made by the competent authorities.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found here: https://coronavirus.data.gov.uk/ and https://github.com/KimLopezGuell/Covid-passport/blob/main/Covid_passport.r.

Author contributions

KL-G is a MSc student in Mathematical Sciences at the University of Oxford. She contributed to the formal analysis, creating tables and figures, and writing the original draft of the paper. AP-U is a DPhil student in the Pharmacoepidemiology

group at the Centre for Statistics in Medicine (CSM) (Oxford) and an MD. He helped with the conceptualization of the project and also contributed to the formal analysis of the data and reviewed and edited the final written paper. MC is a postdoctoral scholar in the Pharmacoepidemiology group at the Centre for Statistics in Medicine (CSM) (Oxford), who also helped with the editing and review of the paper. CP is an Associate professor at the Computational Biology and Complex Systems group at the Universitat Politècnica de Catalunya. She helped with the conceptualization and editing and review of the paper. JH is a Professor of Bioinformatics at the University of Oxford. He helped with the editing and review of the paper. DP-A is a Professor of Pharmaco-and Device Epidemiology at the Centre for Statistics in Medicine (CSM) (Oxford) and an MD. He contributed to the conceptualization, formal analysis, and editing and review of the paper. He is the guarantor of the article. All authors contributed to the article and approved the submitted version.

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Conflict of interest

All authors have completed the Unified Competing Interest form (available on request from the corresponding author) and declare: DP-A's research group has received grant support from Amgen, Chesi-Taylor, Novartis, and UCB Biopharma. His department has received advisory or consultancy fees from Amgen, Astellas, AstraZeneca, Johnson, and Johnson and UCB Biopharma and fees for speaker services from Amgen and UCB Biopharma. Janssen, on behalf of IMI-funded EHDEN and EMIF consortiums, and Synapse Management Partners have supported training programmes organized by DPAs department and open for external participants organized by his department outside submitted work. CP's university has received consulting fees funds from Janssen Cilag SA.

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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.2023.1019223/full#supplementary-material

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Global narratives on unequal outcomes produced by lockdown in Africa: A social science perspective on the "one-size-fits all" COVID-19 response

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Introduction: Lockdown measures were introduced worldwide to prevent the spread of COVID-19, and several studies showed the positive impacts of these policies in places such as China and Europe. Many African governments also imposed lockdowns at the beginning of the pandemic. These lockdowns met with mixed reactions; some were positive, but others focused on concerns about the consequences of lockdowns.

Methods: In this article, we use social listening to examine social media narratives to investigate how people balanced concerns about preventing the spread of COVID-19 with other priorities. Analyzing social media conversations is one way of accessing different voices in real time, including those that often go unheard. As internet access grows and social media becomes more popular in Africa, it provides a different space for engagement, allowing people to connect with opinions outside of their own conceptual frameworks and disrupting hierarchies of how knowledge is shaped.

Results: This article indicates which narratives were favored by different organizations, stakeholders, and the general public, and which of these narratives are most dominant in policy discourses. The range of narratives is found to be reflective of the blindness to inequality and social difference of much decision-making by policymakers.

Discussion: Thus, contrary to the "we are all in this together" narrative, diseases and public health responses to them clearly discriminate, accentuating long-standing structural inequalities locally, nationally, and globally, as well as interplaying with multiple, dynamic, and negotiated sources of marginalization. These and other insights from this article could play a useful role in understanding and interpreting how social media could be included in pandemic preparedness plans.

KEYWORDS

COVID-19, social media, anthropology, narratives, Twitter, lockdown

Introduction

Social media and COVID-19

Researchers have highlighted the social aspects of the COVID-19 pandemic, both in its spread and impacts. In their 2020 commentary, De Ver Dye et al. (1) wrote "COVID-19 is equally—if not more—a socially driven disease as much as a biomedical disease". In our article, we analyse global online conversations and narratives that circulated on social media about lockdowns in Africa, using this evidence to investigate the different perspectives that contributed to policy decisions during the pandemic.

Technology and social media were used on a vast scale to keep people informed, productive, and connected at the beginning of the COVID-19 pandemic. This also contributed to an infodemic that continues to undermine the global response and jeopardize control measures. Social media use was also widespread during previous outbreaks, for example, Ebola, Zika, and Nipah, but the lack of human contact during the COVID-19 lockdowns made it an even more important source of social connection (2–4). Social media changed the way organizations communicated with their stakeholders as well as provided new opportunities for stakeholders to engage in direct dialogue with organizations and each other (5, 6).

We examined these different uses of social media and the narratives contained within them by analyzing posts on Twitter from more than half of the countries in sub-Saharan Africa. Tweets document in real time the cultural and political-economic contexts, community responses and reactions, and the differential effects of lockdown. In this social media analysis, we examine official statements from national, international, and government organizations on lockdown approaches, as well as public opinion, and we further consider the following six narratives that emerged: anti-lockdown, COVID-19 prevention, false dichotomy, poverty, suspicions of motives, and success.

Pandemic preparedness and response are not neutral, technical endeavors, but are profoundly shaped by geopolitical processes (7). There are inherent imbalances of power in policy contexts in terms of which voices and narratives are heard and contribute to decision-making. This article explores which narratives are favored by different organizations, stakeholders, and the general public, and which are most dominant in policy discourses. Our findings are used to reflect upon the lessons these different perspectives in pandemic preparedness and response might offer for future measures.

Lockdowns as pandemic response in Africa

A few days after COVID-19 was declared a public health emergency of international concern on 23 January 2020, the WHO Emergency Committee recommended that all African countries should be prepared for containment including "active surveillance, early detection, isolation, and case management, contact tracing and prevention of onward spread", despite COVID-19 having not yet reached sub-Saharan Africa (8). A range of public health preventive measures were put into action including lockdowns, partly based in some countries on their experience with Ebola in 2014–2016 and considering the difficulties met by European countries confronted by high numbers of cases during the same period.

The first confirmed case in sub-Saharan Africa was announced in Nigeria at the end of February 2020, and the COVID-19 outbreak was declared a pandemic on 11th March (9, 10). The first country to implement a lockdown in the WHO African Region was Rwanda on 21st March, and within 1 month, 11 additional countries followed. A further 10 instituted partial lockdowns of cities or high-risk communities (8). Within 3 months, the virus had spread throughout the continent, with Lesotho reporting a case on 13th May (11). The African continent had been spared for 5 weeks by the limitation of its exchanges with Asia, but its proximity with Europe, a secondary epidemic area, ended this "preparation period". As part of the response, the most exposed African countries rapidly adopted additional public health measures such as border screening and instituted other restrictions such as lockdowns and curfews.

Modeling studies anticipated that African countries would reach 10,000 cases by April 2020 (12). However, many countries were compelled to ease their lockdown measures due to adverse social and economic impact and rising protests, especially when they started considering that the pandemic might last longer than anticipated. We used this information to determine the period we analyse in this article, focusing on the start of the lockdowns and people's opinions as the impacts of the lockdowns were felt, and considering which narratives were used to inform policy and which are marginalized.

Ghana was the first sub-Saharan country to lift its partial lockdown in Accra and Kumasi. However, other restrictions remained in place, and the Government stressed that the end of the lockdown did not mean the end of the pandemic. From January 2020 to January 2021, the Republic of Congo had the longest lockdown period of 294 days (stay-at-home orders with only some exceptions, e.g. for essential trips, daily exercise, or grocery shopping) in sub-Saharan Africa. Nigeria (293 days) and Guinea (292 days) were among the other countries with long lockdowns. Côte d'Ivoire, Ethiopia, Mali, Malawi, and Niger did not have nationwide lockdowns in this period, and Mozambique only had a 1-day lockdown (13).

Many of the tweets that we analyzed illustrated that the situation was both different and more difficult in Africa than in many other locations, for example, a lack of access to running water inside homes, and people living day-to-day, making it difficult for them to stock up on food and essentials (14). For women and other vulnerable groups, the "stay at home" instructions had catastrophic consequences as they were already confronting precarity, and diverse livelihoods and lifestyles were not taken into account (14). In some places, these factors led to protests about the effects of lockdowns to which governments often responded strongly and with violence (7, 15). Some people began to think of COVID-19 as a pretext being used by the government to enact violence and policing.

Methods

Twitter, which was launched in 2006, has quickly grown to be one of the most popular social media platforms in terms of use (3), and it is also the most popular form of social media used for health information (16). Previous studies have used Twitter to track infectious disease outbreaks, natural disasters, drug use, and more (3, 17–19). Many individuals turn to Twitter and other social media networks for clarification and discussion. Pandemic-related discussions include issues such as the economy, school closure, lack of medical supplies and personnel, and social distancing. Along with "ordinary" citizens, African celebrities, scholars, political leaders, and companies rapidly joined the global conversation about COVID-19 as the pandemic emerged.

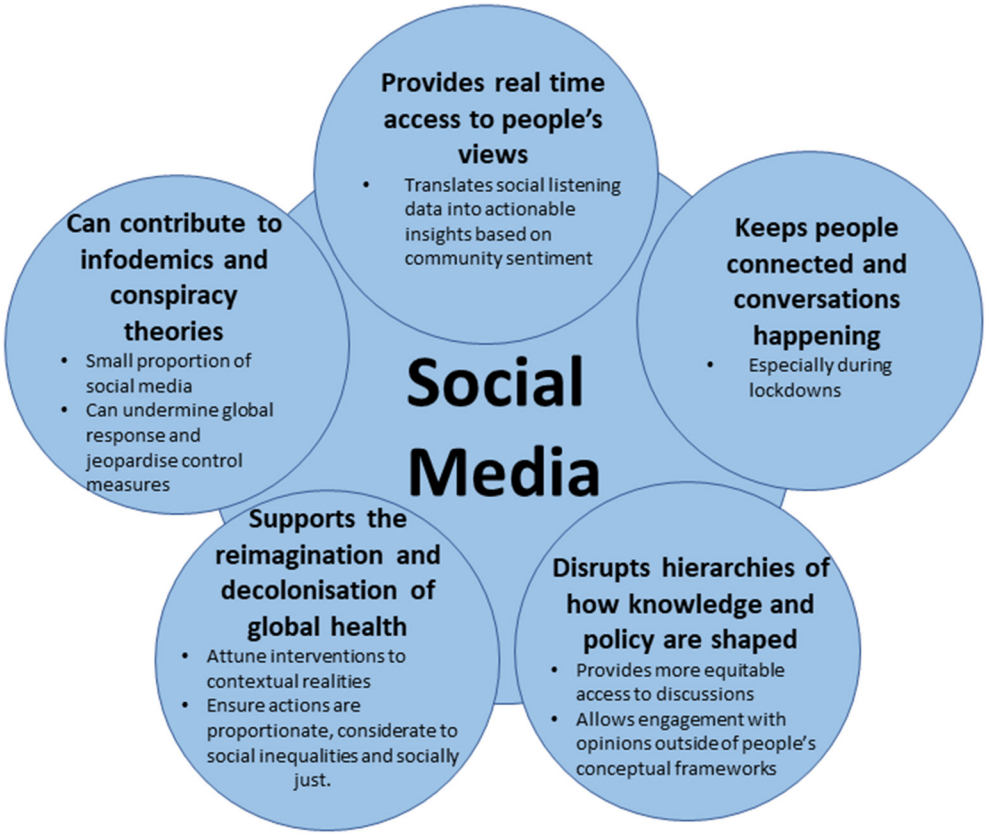

FIGURE 1
Social media during a pandemic.

This article analyses the dynamic spread of information. Figure 1 outlines the benefits of social media during a pandemic; social media messages are available in real time and provide a useful snapshot of global conversations through official accounts of national, regional, and international organizations sharing policy and messages and the real-time reaction of public figures, ordinary citizens, and the conversations between these people. These sources offer an opportunity for early insight into the public's reaction to public health emergencies and responses. In addition, understanding individual decisions in a world where communications and information move instantly *via* mobile phones and the internet contributes to the development and implementation of policies aimed at stopping or ameliorating the spread of diseases (20). The main question guiding our research is: What narratives were circulated online about the benefits and disadvantages of lockdowns to prevent the spread of COVID-19 in Africa?

Although social media users have specific characteristics and may not be representative of the general public, as internet use varies by country from 4.6 to 85% of the population (21), these narratives are important to highlight some of the conversations that occurred globally about COVID-19 lockdowns in Africa. Additional triangulation could be done with data gathered from offline conversations, but this is beyond the scope of our study. Twitter is among the most visited websites in most African countries and gives us a snapshot of conversations within and about Africa from Africans and worldwide social media users (21–23). The observations and recommendations that emerge from the findings of this research can improve our understanding of narratives around lockdowns and which narratives were most dominant on social media. For ethical reasons, to protect individual privacy, we do not identify tweets from personal accounts or academics but we have quoted official accounts (verified by a blue tick), such as those belonging to newspapers.

Data collection and analysis

Data analyzed in this study were collected using Meltwater (social media monitoring software). Online searches using this software identified tweets containing the key hashtags #COVID19 and #Africa. We searched 3 months of data, starting 1 week before the first lockdown in Africa, to examine online responses during the first COVID-19 lockdown period. We identified 103,655 tweets using the two hashtags in the 3 months between 14 March and 14 June 2020. These dates were chosen as we decided to start the search 1 week before the first lockdown so reactions to these being enacted and the announcements of the lockdowns could be analyzed. After removing duplicates, retweets (when someone shares an original tweet), and non-English language results, tweets were analyzed for themes using a grounded

theory approach in NVivo, allowing the ideas and concepts to "emerge" from the data. The first author read each tweet and noted key themes shared by the tweets, then the data was uploaded into NVivo, and codes were made of the key themes; each tweet was manually assigned to a code. Through this process, six key themes emerged. The threshold for a theme to be included was that it contained at least 10% of the tweets. Any theme that contained less than 10% of the tweets was not considered representative enough to be included. In the instance when a tweet was retweeted several times, only the first tweet and any other tweets that appeared to have relevant comments were downloaded. A total of 5,421 tweets mentioned lockdown, and this was reduced to 2,962 when retweets were taken out. These 2,962 tweets were uploaded into NVivo, and emerging narratives were identified based on the data.

Results: Six key narratives

Six key narratives emerged from the analysis. These are outlined in Figure 2 and Table 1.

How dominant were each of the narratives?

Social media listening revealed different narratives. As Figure 3 shows, some narratives were more dominant than others, with the anti-lockdown narrative being the most prevalent in the discussion and the narrative that included conspiracy theories and suspicions of motives the least prevalent. However, as Table 2 shows, all narratives discussed in this article represented over 10% of the discussion so are salient enough to be included in the analysis.

How global were conversations about COVID-19 lockdowns in Africa?

Although 1,097 (37%) of the analyzed tweets were not geo-identified by country,[1] much of the conversation was driven by Twitter users based in Africa. Of the 1,864 (63%) posts that were geo-identified, 49% were uploaded from sub-Saharan Africa. A total of 28 sub-Saharan countries were represented, accounting for 61% of countries in the region. These included: Angola, Botswana, Burkina Faso, Cameroon, Central African Republic, Congo, Côte D'Ivoire, Djibouti, Eritrea, Eswatini, Ethiopia, Ghana, Kenya, Lesotho, Madagascar, Malawi, Mozambique, Namibia, Nigeria, Rwanda, Senegal, Sierra Leone, Somalia, South Africa, Uganda, Western Sahara, Zambia, and Zimbabwe. The three sub-Saharan African countries that contributed to these social media conversations the most are as follows: Nigeria with 34% of the tweets from sub-Saharan Africa, South Africa with 22%, and

1 Enabling precise location allows Twitter users to selectively add location information to tweets. This feature is off by default and requires opting in. This allows Twitter to collect, store, and use the precise location when a tweet is posted, such as GPS information.

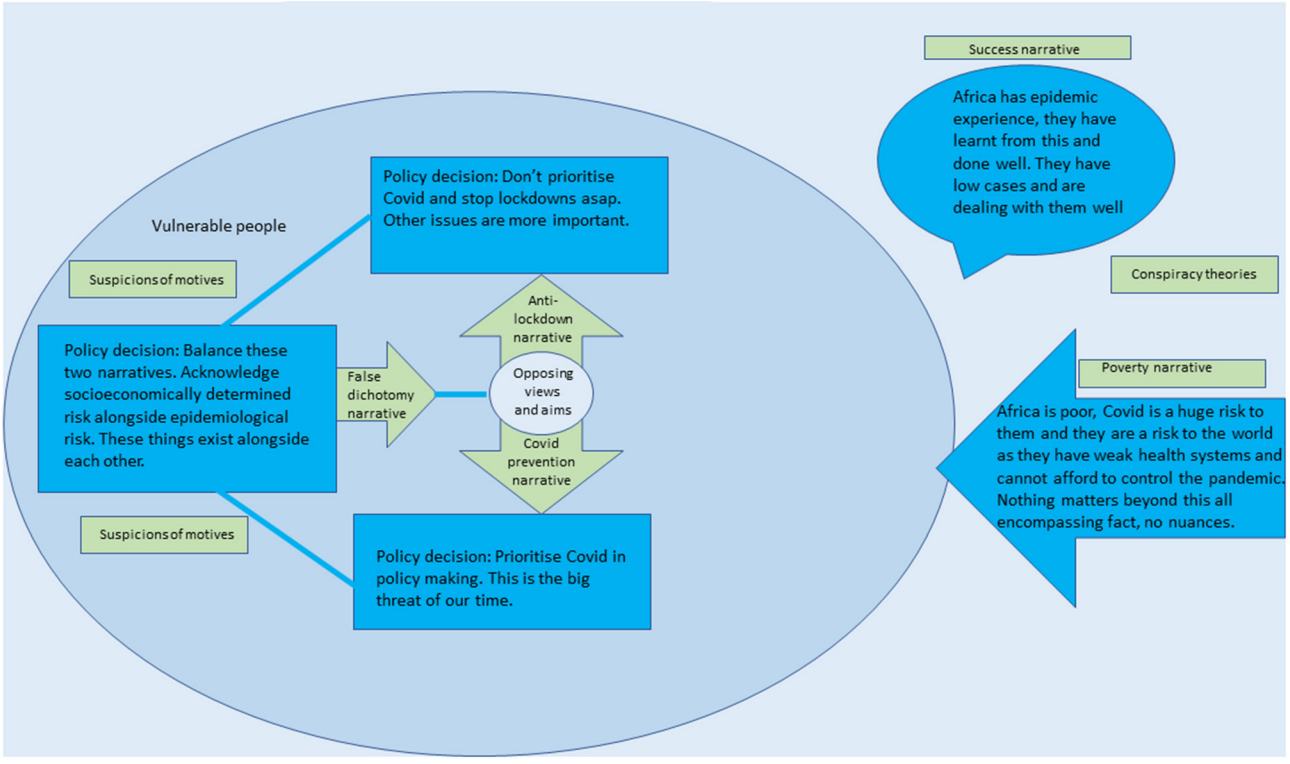

FIGURE 2
Six key narratives.

TABLE 1 Summary of the six key narratives.

Narrative	Summary	Actors that generally support this
Anti-lockdown	COVID-19 prevention is not a key priority and lockdowns should be stopped. Other issues, especially those affecting vulnerable people are more important.	Personal accounts posting from within sub-Saharan Africa.
COVID-19 prevention	Prioritize COVID in policymaking. This is the big threat of our time; nothing is as important as this.	WHO, larger representation of tweets outside of Africa, several health ministers.
False dichotomy	Balance the above two narratives. Acknowledge socioeconomically determined risk alongside epidemiological risk. These things exist alongside each other; policy should not choose between saving lives and livelihoods.	Global organizations and academics.
Poverty	Africa is poor, the pandemic is a huge risk to them and they're a risk to the world as they have weak health systems and cannot afford to control the pandemic so will facilitate the spread of COVID.	This view is prevalent outside of Africa.
Success	Africa has epidemic experience, they have learnt from this and know how to respond. They have low cases and are dealing with them well. Africa is good at effective policy making.	Africa CDC, patriotic Africans, African NGOs and organizations.
Suspicions of motives	Suspicious of vaccinations and the source of COVID and the motives behind lockdowns and government policies.	Unofficial accounts and anti-vaxxers.

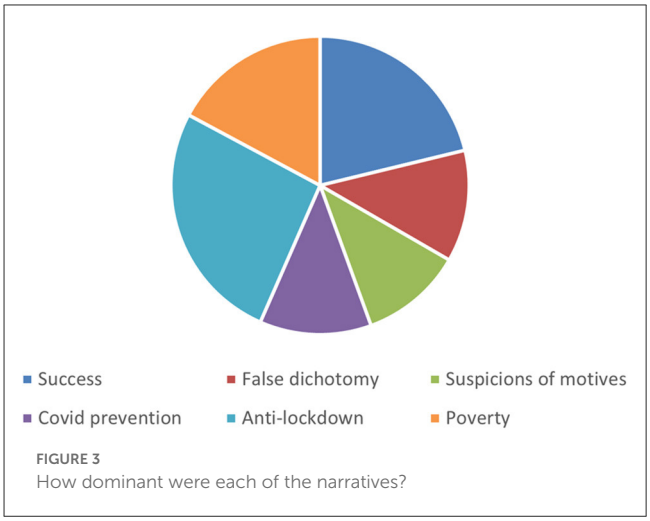

FIGURE 3
How dominant were each of the narratives?

TABLE 2 The prevalence of tweets in each narrative.

Anti-lockdown	25.6%
Success	23.2%
Poverty	16.3%
COVID prevention	12%
False dichotomy	11.8%
Suspicions of motives	11.1%
Total	100%

Kenya with 13%. An important contribution was also made by the Democratic Republic of Congo, Ethiopia, Ghana, Tanzania, Uganda, and Zimbabwe, with the other countries representing around 1% or fewer of the tweets. Figure 4 shows the larger contributions in dark blue, fading to lighter blue and then gray for no contribution. We have not included countries outside of sub-Saharan Africa on the map. Figures 5, 6 show the contribution of different countries to the Twitter conversation.

Official and unofficial accounts: Who was saying what?

The next stage of the analysis was to review the most influential authors for the searched hashtags. The top three accounts (with the most followers) were all official accounts (with blue verification ticks) and were newspapers or magazine Twitter accounts. Table 3 shows the number of followers they had when they tweeted, their reach (how many people read the tweet), and top tweets. The top 10 tweets (read by the most people) were all from official accounts. Individual, personal accounts did appear in the top 25 most read tweets including the 11th most read tweet with 60,300 followers and a reach of 51,431 people, the 16th most read with 26,900 followers and a reach of 28,564, and finally the 21st most read tweet with 16,700 followers and a reach of 15,971. We have not included a table for personal accounts to protect the privacy of these tweeters, but these tweets were still analyzed as part of the data analysis, and many showed an anti-lockdown narrative.

Harmful effects of lockdowns: Anti-lockdown narrative

Tweets circulating anti-lockdown narratives focused on the negative effects of lockdown on people, livelihoods, and economies. This was the most dominant narrative, as it was represented in over a quarter of the tweets (25.3%). This narrative contained several sub-categories, including (1) comparing African countries with other countries outside the continent and highlighting that "one size does not fit all", (2) describing the violent enforcement of lockdowns, and (3) comparing government responses between African countries. The actors supporting this narrative argued that policymakers should consider issues provoked by lockdowns that

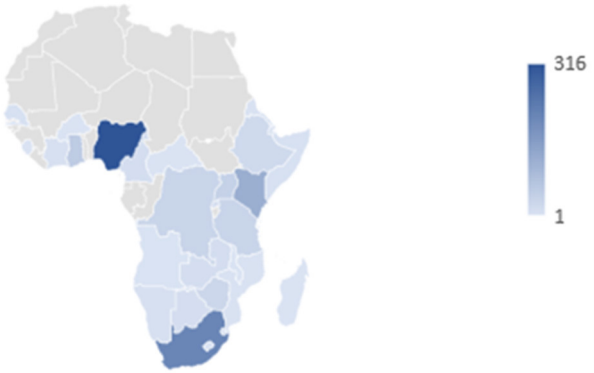

FIGURE 4
Map showing which countries in sub-saharan Africa were part of the social media conversations.

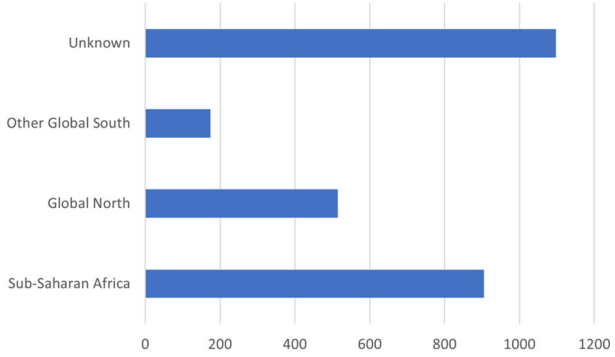

FIGURE 5
Global distribution of the tweets.

may pose a greater threat than COVID-19 to populations in Africa, especially to people already experiencing vulnerability.

Several posts critiqued policymakers for not considering the unique contexts of African countries and for establishing harmful public health response measures. One post summarized this perspective, "Due to existing poverty and lack of facilities, such as indoor washing facilities in Africa #panic #lockdowns, first by #China and later in the #western world as well as #flight #bans by the western world have replicated into #Africa in such a way that widespread #hunger and #diseases is expected, all together worse than the #COVID19 #pandemic itself". Many tweets referred to the lockdowns as "Europe-style #lockdowns" and labeled the policies as foreign. The Cable newspaper, based in Nigeria, pointed out in a tweet that "Africa's economy is fundamentally informal, and the governments do not have the resources to pay their citizens to stay at home as the US and EU countries are currently doing." Another Nigerian tweeter urged Africa to find "its own response" as "WHO #lockdown template will leave nothing left at the end of the day".

Scholars and academics also engaged in these Twitter conservations around "foreign style lockdowns" such as an advisor from Oxfam who shared a blog (24) on Twitter with the comment "A practice emanating from older and wealthier countries was misguidedly 'copy and pasted' by elites in younger and poorer societies". Other academics amplified this narrative and re tweeted this article, such as a Research Fellow at the University of Oxford who shared this article with the comment, "Different demography and different health system means different distancing strategy for #Africa in #COVID19".

Other tweets described people queuing for food in Africa during lockdowns or described populations being pushed over the poverty line as a result of lockdowns. The World Food Programme warned of a "worsened hunger pandemic as the #coronavirus crisis fuels food shortages, job losses and lockdowns." Many tweets highlighted the different livelihoods of many Africans and their inability to work or access markets, pointing out the effects of lockdowns on this population. "This month #farmers across #Africa are due to start planting for the main growing season. But the #lockdown measures imposed to curb the #COVID19 pandemic risk derailing the harvest, raising fears of mass food shortages and lost income", one post stated.

The resilience of African countries to COVID-19, especially through their demographic strengths and young populations was also highlighted in posts as early as April 2020 as an argument against lockdown (14). Posts posited that for this young population, the benefits of lockdown are limited and likely to be outweighed by the negative effects. Some tweets compared the demographics of populations in Africa with the rest of the world and used this as evidence that lockdowns were not necessary, "Most of its population is very young. COVID mortality rate is same as flu for this age group. Considering this, is lockdown of the entire economy (fragile to begin with) the best approach to proceed with? #Africa".

Other tweets leveraged evidence of violence in lockdown enforcement to argue against lockdowns as a way of stopping the spread of COVID-19. One pointed out that there has been "police brutality and deaths by police killing in places where there has been 0 COVID death". In a similar vein, some tweets argued that the impact of COVID-19 had been exacerbated by military involvement, for example, a tweet about South Africa argued that the "heavy cross" of COVID had been made heavier by military involvement. Others referred to the COVID-19 pandemic as a ruse for increased control of the population; "They are just taking their power that you FREELY HANDED THEM. #wakeup #stopthetyranny; In S. #Africa, 3 people were killed as police attacked crowds w/ whips and rubber bullets for defying #COVID19 #lockdown. Five more were killed in #Kenya, including a 13-yr-old boy hit by a stray bullet fired by #police enforcing #lockdown in #Nairobi".

Some tweets compared the effects of lockdowns and their implementation between countries. Posts focused on Nigeria particularly criticized the government, tagging them in tweets and comparing it to other countries, particularly Senegal. An Al Jazeera news report was shared with the comment, "Thank you #Senegal #Africa with this innovative solution fighting #COVID19 and putting the health and welfare of your citizens first but shame on @NigeriaGov [other Twitter users tagged] as they make many Nigerian citizens starve during this lockdown. Well done #Senegal #Africa". "This is what we need in Nigeria. Lockdown should not be the only main approach".

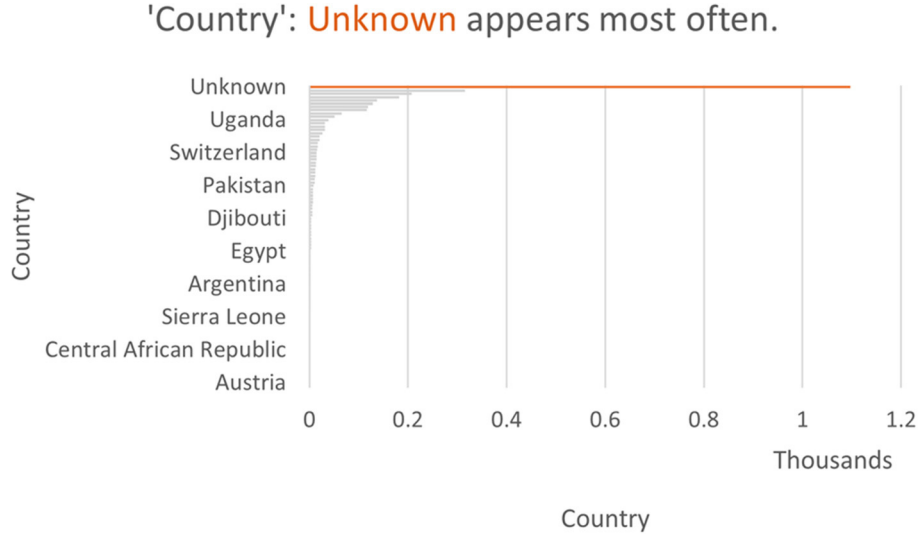

FIGURE 6
The prevalence of different areas in the Twitter conversation.

Importance of lockdowns: COVID-19 prevention narrative

A contrasting key narrative highlighted the importance of taking drastic measures including lockdown to prevent the spread of COVID-19, but this was less represented in the data than the anti-lockdown narrative, with only 12% of tweets demonstrating this narrative. The lack of access to COVID-19 tests in Africa and the unknown incidence of the disease were pointed to as reasons for being extremely cautious. The "worst case scenario" of a rapid spread of infection with many deaths was mobilized in arguments to maintain lockdowns. As lockdowns were lifted, conversations on Twitter reflected ambivalence about the easing of measures. Many tweets critiqued policymakers for lifting these restrictions too early. COVID-19 was positioned in these tweets as the most important threat to the world, including the African continent.

The lack of information on COVID-19 prevalence was mobilized in many tweets to argue for lockdown. Examples were this tweet by a British-Nigerian reporter: "here's the sting in the tail – without mass testing, you risk having asymptomatic people spreading #COVID19 in @Nigeria"; and this tweet from a foreign affairs specialist: "Despite a lack of testing to support low number of recorded #COVID-19 cases and related deaths, #Nigeria plans to ease lockdown restrictions. Praised for handling of Ebola outbreak, leaders are now putting #WestAfrica at risk @ecowas_cedeao? #africa", from a Foreign Affairs Specialist. Many tweeters expressed concern about COVID-19 becoming out of control in Africa, particularly in countries with "huge informal settlements where the virus could spread like an explosion" as mentioned in a tweet from a journalist.

Twitter was used as a communication channel to encourage lockdowns in Africa; for example, one tweet warned, "if you do not go into #lockdown #COVID19 will spread like wildfire and many more will die. #Africa". Other messages highlighted fear and argued for an increase in the severity of prevention measures with messages such as "I'm Scared The World Is Not a Safe Place Anymore!" and "Unfortunately the measures taken in most African countries is simply not enough to flatten the curve. Africa needs full lockdowns, adequate education of the public, financial aid, testing kits, doctors, ventilators to battle against COVID-19!!". Other tweets called for a grassroots imitation of lockdown behaviors, "We must act to slow down, break the chain of transmission and flatten the curve".

Global health agencies also used Twitter as a channel to encourage compliance with lockdowns. For example, the WHO urged caution in its tweets as African countries began to ease lockdowns, tweeting "The sacrifice of staying at home and social distancing is required to stop the spread of #COVID19", "this time we have to keep the street empty so we can create memories again", and "avoid fake news, the lockdown hasn't been lifted. Think long-term, #StayAtHomeAndStaySafe". Many tweets shared examples of why it was too soon to ease lockdowns, and the story was followed globally on Twitter. For example, Qatari press tweeted the following quote from the South African Health Minister Zweli Mkhize: "the rate of new #coronavirus infections in #SouthAfrica has to slow before the country can lift a nationwide #lockdown in line with World Health Organization guidelines".

As lockdowns began to be lifted in some African countries, many tweets questioned the end of these lockdowns, arguing that restrictions were lifted too early. Following the end of the lockdown in Ghana, for example, tweets appeared such as one by an African blogger who questioned, "So why is Ghana Lockdown over? #COVID19 cases continue to increase in #Africa" and "Ghana's easing of #lockdown was a relief to the poor, but many (including myself) feel it was premature to lift the lockdown when infections numbers are still rising". Others called for action and re-instatement of lockdowns, "President @NakufoAddo has to reinstate the lockdown before thousands of #Ghanians perish. Other African countries contemplating the same route should think twice". Similar tweets about Nigeria emerged following the easing of lockdowns in that country: "#Nigeria has recorded its highest

TABLE 3 The tweets with the highest reach.

Name	Followers (as of Jan 2022)	Reach for top tweet in the data	Tweet
The Guardian Nigeria (@guardiannigeria)	2.2 million	1,738,366	Here is why you should pick up a copy of The Guardian on Tuesday #Coronavirus #COVID19 #NDDCWorkers #Tax #BokoHaram #Terrorists #NorthEast #Buhari #Kogi #NewZealand #Lockdown #Yobo #NPFL #Nigeria #Africa #Headlines #TNT #TheGuardianTNT #News #TomorrowsNewsToday #TheGuardianNg https://t.co/UcyjpEp71a
allAfrica.com (@allafrica)	456,200	405,518	Higher Education Budgets Key to Securing Africa's Future After COVID-19: https://t.co/LnEsJal6AT #Africa #lockdownlife #backtoschool #COVID19 #CoronavirusinAfrica #level3lockdown @ONECampaign @edwindaniels1 https://t.co/kbck3LsbdN
The Africa Report (@theafricareport)	209,100	163,570	#Women during #COVID19: Across #Africa, 44% of women experience #abuse by their partners. During #lockdown conditions, that figure has nearly tripled in certain countries, reports @tofeayeni https://t.co/tkGCHbkmdo

single-day infection rate of #COVID19, the day #Africa's biggest economy began a six-week phase-out period of the emergency lockdown measures. A total of 245 new cases were confirmed on Monday in Lagos".

The juxtaposition of lockdown narratives: False dichotomy narrative

A third narrative found in tweets during this time critiqued policymakers for creating an illusion of dichotomy by juxtaposing economic activity against epidemiological risk, rather than acknowledging socioeconomically determined risk alongside epidemiological risk and this was represented in 11.8% of the tweets (25). These posts argued that the two narratives described above should not be thought of as mutually exclusive responses. Many tweeters called for a balance between the narratives of anti-lockdown and COVID-19 prevention. Tweets that supported this narrative argued that these factors exist alongside each other and called for a comprehensive public health approach to address social determinants and medical requirements simultaneously, with equity as an overarching principle. Alternative models to epidemic response were demanded by tweeters, that allowed for the management of pandemics in ways that would not require choosing between saving lives and saving livelihoods.

While this narrative was less prevalent on social media than in official communication from the global health community, there were still many arguments for this approach. These messages were often tweeted by experts. For example, a Fellow from the Wellcome Sanger Institute tweeted that, "full lockdowns work in reducing disease transmission, but in #Africa this is likely to be very damaging. Responses must strike a balance between saving lives from #COVID19 and averting massive disruptions to livelihoods, which in the end translates into lives lost". "While there are still many unknowns and caveats, we need to leverage our data to make informed evidence-based decisions for sustainable solutions with minimal detriment to lives and our fragile economies."

This more balanced approach was also seen as a step away from the initial Western-driven policy decisions, and as the pandemic continued this entered mainstream debates more and more. A professor at a university in New York tweeted "we're looking beyond the West to understand how to manage pandemics in ways that don't require choosing between saving lives and saving livelihoods". Tweeters also focused on different sectors where a balance was needed, referring to these as all "inextricably linked", in the words of experts from the Africa Union Africa Vaccine Delivery Alliance for COVID and the Global Health Academy. These tweets contained strong emotive language and critiqued policymakers for positioning decisions around lockdowns as "a battle between lives and livelihoods" with the stark choice of "starve or get sick".

Some more balanced solutions were offered, especially by professional bodies or people. For example, an epidemiologist at the London School of Health and Tropical Medicine tweeted "intervention strategies in #Africa could combine self-isolation, moderate #PhysicalDistancing and shielding for the most effective #COVID19 response". An economist from Nigeria posted that "solutions need to be multidimensional, far beyond economics and western medicine".

Poor health outcomes and health infrastructure in Africa were highlighted as evidence that essential services should be balanced with prevention measures as "COVID-19 is not the biggest public health risk that Africa faces". Several organizations also tweeted messages about balancing lockdowns with health threats, including Health Policy Watch, based in Geneva, that pointed out that "lifting #lockdowns…may prevent deaths from other causes, like #malaria, #AIDS & #TB". Another key issue faced in Africa was the difficulty accessing foreign remittances during lockdowns. Some policymakers were described as "easing lockdown restrictions so that people can access funds sent by family members. Hopefully, this doesn't compound local transmission…how do we balance".

Harms of lockdowns in Africa: Poverty narrative

A fourth narrative found in tweets, especially salient outside of the continent, focused on Africa's poverty and weak health systems as a risk factor for both the spread of the pandemic and the negative consequences of sustained lockdowns. This narrative focused on Africa as a source of risk for the rest of the world, catalyzed by its poverty, and was represented by 16.3% of the tweets in this data. This narrative carried an underlying current that "no one will be safe until everyone is safe" as tweeted by a UN coordinator. Other tweets echoed these fears asserting, "Africa is sitting on a COVID−19 humanitarian catastrophic time-bomb and waiting to explode!" and "you don't wanna think about this hitting Africa hard".

Statistics about poverty in Africa were often mobilized in tweets related to the pandemic and lockdown in Africa, such as one tweeter who argued, "#COVID19 social and economic impacts on a very #unequal #Africa where majority lives below $2 a day. People are struggling & wud rather die of virus than being locked down. Things may explode if we don't work together to address issues on the ground". More specific issues related to disease risk were also highlighted in tweets, such as "#COVID19 is a huge threat to people with underlying health conditions, which are concentrated predominantly among those who live in abject poverty". Specific examples of the synergetic effects of lockdowns and poverty were described in country contexts, such as "Uganda's lockdown has decimated the incomes of many informal traders' or 'thousands of people surged for food aid in a stampede Friday in Nairobi's Kibera slum, desperate for help as coronavirus restrictions keep them from making a living".

African demography was a key issue in tweets as well, "Different demography and different health system means different distancing strategy for #Africa". "A practice emanating from older and wealthier countries was misguidedly copy and pasted by elites in younger and poorer societies". "Most low-income countries esp. in sub-Saharan #Africa, where more than 70% of the population is young, can avoid complete #COVID19 lockdown by sending their young population to work. Those who are at high risk – the elderly, and with underlying conditions can #StayHome".

Some tweets centered narratives about African poverty within a greater context of concern about the economic interests of China on the continent, suggesting that the pandemic was a foreshadowing of economic destruction to come. For example, one tweet posited, "New trade statistics reveal a 14% drop in trade volumes between #China and #Africa in the first quarter. If #COVID19 lockdowns last in Africa and the racism controversy in Guangzhou continues to erode China's image, this figure could get a whole lot worse". Other tweets compared China to Africa when focusing on the dangers of live animal markets spreading diseases and asserted that "China blames #COVID19 on Africans". In response to this tweet, one tweeter replied that "there are 1000 times more Chinese [in] #Africa vs. Africans [in] #China", and another replied that "If #ChinaLiedAndPeopleDied are doing this #AfricansAreNotLabRats we round them up too and send them back too".

Several tweets directly challenged this narrative, such as those that shared an article written by two PhD students titled "Let's Decolonize the Coronavirus" (26) or tweets such as "the pandemic has become the latest incarnation of the persistent discourse about the continent's destiny to fail" and "coverage of #COVID19 on Africa has been used to perpetuate stereotypes about the continent". One tweeter summed up amazement at the Western focus on Africa's lockdowns, writing, "I am so intrigued by the West's focus on Africa although countries [outside Africa] were implementing strict measures with little or no cases present".

Many tweets used arguments about public perceptions of the origins of COVID-19 in their critique of the poverty narrative. These tweets stated that even though the pandemic had originated in China there was a desire to blame Africans for its spread. This included a focus on live animal markets, and tweets that connected these with lockdowns, such as "there has been an alarming increase in bushmeat harvest and wildlife trafficking that is directly linked to #COVID19-related lockdowns, decreased food availability and damaged economies as a result of tourism collapses". Twitter users pushed back at these stereotypes with statements such as, "This is way too sensational and definitely does not represent the #africa I live in. I'm disappointed in this. The article has no #scientific

backing, yet it sounds alarmist. Neither #poaching or #bushmeat harvesting is not on the rise! #FactCheck". Some tweets critiqued international media for trying to "deflect" attention away from troubles "at home" by focusing on Africa and urged international writers outside of Africa to focus on their own issues. A tweeter from Zimbabwe posted that "Africa really needs to try and work hard to keep these Eurocentric journalists from always expecting the worst".

Lockdowns work: Success narrative

Narratives focused on the success of lockdown measures argued that the African continent responded well to the pandemic, as demonstrated by low case numbers; this narrative appeared once the epidemiology became evident. These narratives of success were especially salient in tweets posted by African NGOs and agencies and were the second most dominant category with 23.2% of tweets being assigned to this narrative. Many of these tweets mobilized ideas about Africa's previous experience in confronting infectious diseases. Tweeters highlighted the need for home-grown solutions and embraced lockdowns as an African-led response. Tweets about the success of African countries in preventing the destruction by the pandemic that had been predicted by the West also highlighted the success of the continent in general. For example, "Truly, #Africa is great. Africa is my continent. Africa has great people, great cities, and great culture. Our brain is the best. Africa is bigger than any challenge. We are strong people', before going on to compliment the continent on its 'commendable progress in tackling the virus".

Many tweeters expressed a feeling that the world was being too critical of the continent's capabilities and called for optimism: "it's not going to rocket. Stop trying to push your agenda. You always think Africa isn't capable of overcoming global issues. It's 2020 report the truth!". Other tweeters used narratives of success to support general hope for the people and products of the continent. "This is the best time to promote locally made products and services. Let consume our own. #Africa" or "so many of the women scientists and public health experts stepping up and being heard across Africa". Other tweets highlighted the pandemic as an opportunity for the continent, such as a tweet from Zambia that summarized, "as it stands Africa hasn't been much affected by the #COVID19 pandemic and this is supposed to be an opportunity for #Africa to invest in the manufacturing, agriculture and Infotech and biotech industries because the world is in more chaos and under total lockdown".

As news about the progression of the pandemic in Africa emerged, many tweets compared outcomes on the continent with those in other places, for example, "So far African countries have fared far better than more developed, richer countries, experiencing a much lower rate of infection from COVID-19", or "I don't care what anyone says, but for a continent with poor healthcare, infrastructure and sanitation, Africa has done amazingly well. Yes, there are numerous shortcomings but African governments should praise their citizens". Africa was situated in this narrative by some as a model for the rest of the world in the COVID-19 response. One tweet posed the question, "Can someone let me know when Republican leaders in the US say we must follow Africa's lead on the coronavirus?". Several tweets attributed Africa's perceived "success" against the virus to the continent's experience confronting the spread of other infectious diseases, such as one post that stated "Africa has plenty to be hopeful about, with lessons learned from previous epidemics".

Several tweets focused on the successful implementation of lockdowns, in addition to the successful outcomes of these lockdowns in preventing the spread of disease. One post shared a quote from a former governor of the Central Bank of Nigeria: "we should think African…act locally and opportunistically to survive and prosper, and exploit the global opportunities offered by the crises. Solutions need to be multidimensional, far beyond economics and western medicine". Many tweets highlighted the success of technology in keeping people connected to one another and essential services such as education during lockdowns, for example, "#radios for classroom listening and school lessons at home because of #COVID19. Radio #technology keeps children learning" or "with 1.5 billion+ students in 188 countries currently out of their classrooms due to #COVID19 lockdown, learners are turning to their #smartphones and in spite of internet access, data costs & power, edtech companies in #africa are stepping in".

Support from African businesses and individuals in successfully navigating lockdowns was also highlighted, such as the work of Nigerian filmmaker Niyi Akinmolayan who "created an animated short film to help kids understand and cope with Coronavirus related lockdowns and changes. Well done!" or the "Kenyan nutritionist[…]keeping schoolkids fed". Many of these posts promoted the work of African women artisans, such as "talented #Nigerian artist Marcellina Akpojotor […] is using 12kara / wax print fabric to make amazing art and maintain her positivity during the #COVID19 #lockdown". The work of these women and craftspeople was lauded as supporting resilience in the face of the pandemic and the difficulties posed by lockdowns. Examples of these types of tweets included, "In #Zimbabwe, the women with disabilities have been able to work in the craft industry to make cheap and affordable masks" and "Many small women-owned businesses making the most of #LockdownEaster to stay home, stay safe and sew #facemasks for #africa. That's #resilience of vulnerable people."

Specific national lockdown strategies were shared and complimented in many tweets, including those mitigating the negative effects of lockdown, such as, "#Namibia is introducing an Emergency Income Grant system for people whose livelihoods are affected by the #COVID19 lockdown", or the success of these lockdowns in preventing the spread of the pandemic, for example, "#Mauritius has 'won', the #Coronavirus battle as the last patients are discharged. Imposed one of the strictest lockdowns in #Africa – initially shutting supermarkets for 10 days. Short term pain for long term gain". Other tweets directly attributed political action to the low prevalence of COVID-19 in some countries. For example, "early action to close borders and stop flights, along with social distancing and lockdown, led to 39 traced cases of #COVID-19 in #Eritrea. All have recovered and returned home, no new cases for many days, and the number stands at 0 now!" Another tweeter shared, "in a country with huge informal settlements where the

virus could spread like an explosion. It seems the #lockdown strategy of #SouthAfrica is doing the trick. #StickWithIt".

Suspicions of motives leading to lockdowns: Cautions and conspiracies

A final narrative identified in tweets centered on suspicions about the motives beyond lockdowns and government policies in response to the pandemic; this was the least represented narrative included in our analysis, accounting for only 11.1% of tweets, and was mainly disseminated by unofficial accounts and those identifying as anti-vaxxers. This narrative includes tweets questioning approaches and includes both political opinions and conspiracy theories. Intertwined with narratives that amplified conspiracy theories about COVID-19 and public health response were questions about vaccines and Bill Gates' "prediction" of the pandemic. Political narratives about Western interests in Africa and African destruction were also situated with these conspiracy theories. Many tweets pointed toward the involvement of international organizations and governments in the pandemic response, suggesting that this was part of a greater plan for depopulation. One tweeter posted, "@WHO is trying to scare #Africa so that stupid gvts fund their own pples Depopulation *via* Gates #vaccines" and another (from an account that went on to become suspended) posted that "#Africa are against corrupt WHO and it shareholder Bill Gates for their Evil agenda against world population. #lockDownSouthAfrica End of tyranny".

Some tweets that amplified this narrative quoted Gates as previously discussing overpopulation and questioned the motivations of the Gates Foundation in the COVID response. "He couldn't save #Microsoft from viruses, now he wants to try humans ?????? He's the biggest proponent of depopulating the world. #Africa wakeup!", stated one tweeter. Others reacted to world events and questioned the motives of international leaders, such as "Boris Johnson is in ICU for #COVID #COVID19 #coronavirus yet Bill Gates has a #vaccine he wants to give to #Africa, he must really love us indeed and hate Boris. #AfricansAreNotLabRats" or "#BillGates keep away from Africa and the world for that matter".

These tweets confronted lockdowns and other forms of political response to the pandemic on the continent. Many of these posts used evidence of low COVID-19 prevalence to support claims on the hidden agenda of WHO and other global health agencies. Vaccines and lockdowns were addressed as the flip side of the same coin in these conspiracies. For example, "4.8m #COVID19 infections worldwide, #Africa <150k yet #WHO @WHO wants #vaccine sent to Africa based on unfounded predictions instead of vaccinating 4.6 m active cases in #USA #Eurovision2020. Something doesn't add up #Lockdown".

Narratives that questioned the nefarious intentions of the COVID-19 response often drew upon past experiences with medical experiments on the continent's population and the negative effects of the Global North's interests. "How are Africans expected to not react to yet another attempt to use them as guinea pigs to develop drugs that would serve the Global North??". Another tweeter pointed to COVID-19 lockdowns when they wrote, "this is how unjust and diabolical the world has been to us. They do not regard us as humans in some cases. Sickening….. #Day13ofLockdown #CoronaVirus #COVID19 #WHO #AfricansAreNotLabRats #AfricansAreNotGuineaPigs".

Many tweets brought forward ideas about who was benefiting from lockdowns. Narratives about who benefitted ranged from individual politicians to governments interested in surveillance, or China as well as the Global North. One tweeter expressed, "It's not right that China profits from #COVID19 while the world is on #lockdown." Another post raised the question, "why has new draconian lockdown laws just been extended? Two reasons - the stats you are being fed are lies OR someone is trying to destroy the economy for purposes which can only be dreaded". Narratives about surveillance through public health programmes and lockdowns were also salient. For example, a tweet written by a South African model and actress stated, "SA Government implemented cell phone location tracking of all citizens on Thursday while we on lockdown".

In posts about the political interests fuelling lockdowns, tweeters often pointed toward the inequitable implementation of these lockdowns. "Not everyone was locked down??????; Who gave this people the clearance for the rally just a day after the total lockdown? Or could it be because they were going to declare their allegiance to the President? #SSOT #COVID19 #SouthSudan #Africa", one poster asked. Other tweeters highlighted the displeasure of international governments with African governments that did not decide to completely lockdown, "Some non-African governments are just mad upon those Africans who [d]on't shut down the economic and make a complete lockdown, meanwhile some African governments [want] investment in the crisis politically".

"Home grown" innovation from Africa related to COVID-19 testing and treatment was situated in some posts to fight back against these conspiracies driven from outside the continent. Several posts shared evidence of herbal COVID-19 medication from Madagascar to demonstrate the eventual win of the continent's population against these conspiracies, including lockdown. For example, one tweeter wrote, "#Madagascar medicine is a proof that we #AfricansAreNotLabRats #Africa are against corrupt WHO & it shareholder Bill Gates for their Evil agenda against world population."

Discussion: Lockdown narratives and public policy

The narratives emerging from our analysis of tweets after COVID-19 lockdowns in Africa during the beginning of the pandemic clearly show the politics of lockdown measures. Policymakers were faced with balancing public health action to prevent the spread of COVID-19 with the negative impacts of lockdown measures. People interpreted and responded to this new infectious threat by drawing upon long-standing local frameworks as well as lived experiences. Policy decisions were made alongside voices calling for the consideration of vulnerable people and others sharing conspiracy theories.

If policymakers do not consider different narratives and context-specific perspectives it can reinforce social and economic

inequalities as well as create social resistance. This brings to the fore the reality that epidemic preparedness and response are not neutral scientific processes but steeped in political and social considerations. In addition to scientific data, decision-makers may be unequally influenced by the often-competing narratives shared by different social actors, as well as political and economic concerns. The initial social and scientific uncertainty that surrounded the emerging new disease of COVID-19 may have further increased the tendency to pursue standardized "one size fits all" routes of response which favored disease containment through top-down, state-led interventions (27).

The findings of this social media analysis highlight the importance of listening to different voices and diverse narratives about public health response measures such as lockdowns in Africa. There is a top-down legacy in policymaking and a dichotomy between the knowledgeable policymaker who makes decisions on behalf of unknowledgeable passive populations. Social media analysis is one way of accessing in real time different narratives and amplifying voices as they emerge in response to policy decisions. As internet access grows, social media could provide greater access to these voices. It may also allow people access to opinions outside of their own conceptual frameworks and environment, which is especially valuable during emergencies when people are unable to interact in the usual manner.

The narratives identified here can be useful for interpreting and understanding the levels of impact that lockdowns are perceived to have on different populations. The lifting of lockdowns in Africa, but keeping milder containment measures, as per the false dichotomy narrative, became necessary to save lives, economies, and livelihoods. The poverty and anti-lockdown narratives showed that COVID-19 control strategies led to panic and anxiety in countries where the majority of citizens live below the poverty line and were faced with public health response measures that were not suited to these contexts. In the extreme, some policymakers have been accused of using the pandemic to legitimize excessively authoritarian responses. This may be even more important in people's daily life than the political use of lockdowns, and, being either legitimate or abusive, it can only be stopped by notification at the community level, responsive action at the government level, and with political will (28).

However, as the success narrative argues, the African continent has great recent experience with the epidemic response, and African populations are well versed in how epidemic response can fit within other priorities. This experience should be considered and built upon during each new pandemic in a way not currently realized. The 2013–2016 West Africa Ebola outbreak provided clear evidence that local-level action can be significant in turning epidemics around. During this epidemic, citizens applied past experience of disease control to protect themselves and arrange safe burials and morally acceptable care of kin (29, 30). This showed that social mobilization is a key component because all stakeholders should be involved to enable the pooling of resources and optimizing the management of epidemics (31).

Considering different voices and narratives should be key to creating and implementing effective policies (32). The history and politics of people's relationship to the health system, government, and global actors are key to whether there is trust in communities, which would shape how people explain the disease emergence and how they react to the response (33). How the disease is framed by different actors can shape the course of epidemics including the way the population perceives the disease and the risks it poses, how they engage with response activities, and how the response strategy is designed. Biomedical and epidemiological "expert" evidence may dominate, but this may contrast with local communities' models of disease, knowledge from other disciplines, and information from non-experts (34, 35).

When first-hand experience contradicts health messaging, this may mean people are more likely to question the risk-prevention activities of the response. For lockdowns, as a specific policy decision, narratives will differ in poor countries where people are much less able to cushion the potentially devastating economic impacts produced by lockdowns. Effective lockdowns are near impossible in crowded low-income settlements that lack taps, sewers, and other amenities. Finally, protecting the health system by flattening the curve of cases is less important when populations are young and there is less of a system to protect, but it also diverts attention from addressing other health issues that are dangerous for much of the population, such as malaria, measles, and childbirth (24).

Conclusion

An emerging body of evidence has reported the use of social media to share knowledge about health issues including COVID-19 (36–40). The findings of the research presented in this article show that there were many different competing narratives on Twitter during the initial COVID-19 lockdowns in sub-Saharan Africa. Data from social listening and infodemiology provide an indicator of the sentiment of part of the African population as well as viewpoints on the lockdowns in Africa from around the world. These insights should be included in pandemic preparedness plans for future outbreaks to promote policy decisions that are better aligned with the priorities and perspectives of affected populations.

Social media plays a role in amplifying and gaining access to different voices and narratives that emerge during crisis situations, especially during lockdowns when normal social communication is hindered. Social media will likely play an increasingly prominent role in keeping people connected and (mis)informed. There have been many innovative uses of social media during this pandemic such as crowdsourcing campaigns to gain access to opinions on policies, and as social media grows in Africa, these could be usefully incorporated into the continent in the future (36).

The findings from this research are also important for the development of behavior change communication campaigns, which could also leverage platforms like Twitter which has been shown to be more effective in disseminating information on issues of public concern than formal communication and marketing (38). As policymakers and ordinary citizens navigate health threats by drawing upon available evidence and social

priorities, it is important to recognize the diversity of needs and the contradictions that can exist around health messaging and epidemic response policies.

Data availability statement

Publicly available datasets were analyzed in this study. This data can be found at: IDS OpenDocs.

Ethics statement

Written informed consent was not obtained from the individual(s) for the publication of any potentially identifiable images or data included in this article.

Author contributions

CG and KS conceptualized the study. CG conducted the searches, analyzed, coded the data, and wrote the initial draft of the manuscript. KS provided input during the tasks mentioned previously and co-wrote the manuscript. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Lessons from the stigma of COVID-19 survivors: A Marxist criticism appraisal

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Stigma refers to devalued stereotypes that create barriers for stigmatized individuals. During the COVID-19 pandemic, the stigmatization of survivors worsened existing inequalities and triggered mass hysteria. The paper delves into the stigmatization experienced by COVID-19 survivors and the role of Marxist criticism in analyzing this issue. The main findings from the empiricist tradition approach suggest that the perception of COVID-19 stigma is higher among those who are older, belong to ethnic minorities, lack social support, have manual occupations, and possess lower levels of education. The proposed destigmatization pathways include psychological counseling services, social support, and health education. Employing a Marxist perspective can aid in illuminating how economic practices and material conditions influence prevalent ideologies related to stigma. The stigmatization of COVID-19 survivors may be perceived as a consequence of social power inequality, although the current emphasis on individual characteristics as triggers for stigma may neglect the wider systemic forces in operation. Thus, it's crucial to establish improved social care policies to combat exploitation and oppression due to power imbalances. The ultimate objective of such an examination is to identify effective approaches to tackle and eradicate stigma regarding health-related concerns. An interdisciplinary approach integrating a pluralistic perspective would benefit investigating how social systems and individual attributes contribute to the exacerbation of social inequality and stigmatization.

KEYWORDS

COVID-19 survivors, stigma, inequity, social care policy, Marxism

1. Introduction

Stigma is the epitome of the disharmonious relationship between society and human beings (1, 2). Goffman (3) conceptualized this phenomenon as the "spoiling of identity"; that is, when certain types of people have status standards that do not meet social expectations, they will be demeaned. Disease is one of the most common sources of stigma. During the 2019 coronavirus disease (COVID-19) pandemic, there is no doubt that people infected with COVID-19 were stigmatized around the world (4–9). This stigma has brought large amounts of psychological and physical distress to COVID-19 patients (10, 11).

When infectious diseases with low morbidity and mortality are highly stigmatized, the burden of this stigma can have a negative impact on the overall quality of life in a society (12). The stigmatization of COVID-19 survivors has been captured in many studies around the world. Alchawa et al. (13) found that individuals with some characteristics, such as male manual workers and those with low education levels, had a higher perception of stigmatization when

they surveyed 404 COVID-19 survivors from 41 countries. Latha et al. (14) found that among 150 COVID-19 survivors interviewed in Visakhapatnam, Andhra Pradesh, India, 29.3% faced social discrimination. In addition, the stigmatization of COVID-19 survivors has been found in Nepal (15), Ghana (11), Tunisia (16) and other places.

COVID-19 stigmatization can be seen as a social process to exclude potential sources of disease, as people potentially carrying the virus may pose a threat to the normal functioning of society (17). However, although COVID-19 survivors were infected at some point, they fully recovered; from a medical point of view, they do not pose a transmission risk for the spread of the epidemic. On the contrary, because of the immunity caused by viral infection, they should have a lower risk of spreading the virus than normal people who have not been infected with COVID-19, yet they have suffered greater stigma. In response to this paradoxical social phenomenon, this article hopes to analyze the social dynamics underlie the stigmatization of COVID-19 survivors.

For stigmatization to occur, power must be exercised (18). Thus, the power inequality generated by class relations is an effective way to understand the stigmatization of COVID-19 survivors. However, the role of social power and class locations in stigma is frequently overlooked, as power differences are often taken for granted and seem natural, universal and unproblematic. Meanwhile, some social care research views social class as commonly observable personal attributes and material conditions (19). This empiricist tradition of social class research neglects the study of unobservable social mechanisms (20, 21). This view also treats social care as a purely public health issue, ignoring the impact of power inequality on social care. Unlike most studies that conceptualize class as an individual attribute to identify causes and interventions of stigma (10, 11), we aim to reveal that the inequality of social power is an important driving force for stigma processes. To this end, the social care system must formulate a new response.

Whether in the early days of the HIV epidemic or the current COVID-19 pandemic, the issue of stigma is an important challenge that accompanies infectious diseases (14). The present article aims to provide a holistic understanding of the experiences of stigmatization as experienced by survivors of the COVID-19 pandemic and where current social care policies need to be improved. An understanding of these issues will also help us to better cope with the stigmatizations that have occurred in the past and that will occur in future epidemics.

2. Methods and materials

2.1. Searching strategies and data sources

Articles with the phrases "stigma"/"discrimination"/"stereotype" and "COVID-19 survivors"/"recovered COVID-19 patients"/"Post COVID-19" in the title were obtained from Google Scholar, while articles with the phrases "stigma"/"discrimination"/"stereotype" and "COVID-19 survivors"/"recovered COVID-19 patients"/"Post COVID-19" in the title or abstract were retrieved from PubMed, Elsevier and Web of Science. All titles and abstracts identified in the above electronic databases were screened by 2 authors independently of one another. The full text of each selected article was read one by one to ensure all of them met the research criteria. The literature search period required no setting; the data retrieval period ended on November 30, 2022.

Inclusion criteria: research focused on the stigma (or discrimination, stereotype) of "COVID-19 survivors" (or "recovered COVID-19 patients," "Post COVID-19").

Exclusion criteria: studies without a clear source; articles mentioning "stigma"/"discrimination"/"stereotype" and "COVID-19 survivors"/"recovered COVID-19 patients"/"Post COVID-19" that did not address the research object of this work; and repeatedly published research.

2.2. Marxist criticism

Although the current study of social care is dominated by the empiricist tradition of social class approach, we seek to introduce an alternative approach, a Marxist analysis. This analytical approach promises to advance the study of social care inequalities and provide an intellectual basis for the social change needed to reduce inequalities. The approach of Marxist analysis, elaborated below, can be summarized by a focus on the relations of economic production through the processes of ownership and class, domination and exploitation.

(1) Ownership and class. Any system of production requires the deployment of factors of production, which are commonly classified as land, labor, capital, etc. The way in which these factors of production are deployed forms ownership, or in other words, the social relations of economy. When the power over productive resources is unequally distributed among people, these social relations can be described as class relations (22). As noted by Lenin (23): "Classes are groups of people, one of which can appropriate the labor of another, owing to the different places they occupy in a definite system of social economy."

(2) Domination and exploitation. Class locations—the dominant location and exploited location—can be understood as the social positions occupied by individuals within class relations. Exploitation denotes an unjust social position shaped by an asymmetry of power or the unequal exchange of value between workers and their dominators (employers). According to Marxist theory, the phenomenon of domination and exploitation is a characteristic of all class-based societies, not only capitalism. However, in a capitalist society, the exploited are the proletariat and the exploiters would typically be the bourgeoisie (24).

2.3. Appraisal process

In this article, the appraisal process is conducted in three steps: First, we review the literature from four perspectives: the demographic and sociological characteristics of the stigmatized groups, the mechanism underlying the stigmatization of "COVID-19 survivors," the consequences of stigma and the path to destigmatization. Second, we make a critical appraisal based on

Marxist analysis and propose how to understand the phenomenon of stigma from the perspective of Marxism. Finally, we summarize the conclusions of this study.

3. Current study on stigmatization of COVID-19 survivors

Although research on the stigmatization of patients with COVID-19 is abundant, the literature on the stigmatization of "COVID-19 survivors" is scarce. The number of articles found in the initial search was 35. The following types of documents were not included: repeated publications, content-irrelevant records and other articles, such as literature reviews (16 articles in total). According to the inclusion criteria and exclusion criteria, the final number of articles that were eligible for this study was 19 (Figure 1). Basic information about the included articles can be found in Table 1.

3.1. Characteristics correlated with stigma among COVID-19 survivors

Many studies have shown the pervasiveness of the stigmatization of COVID-19 survivors. For example, in Qatar, more than a quarter of COVID-19 survivors reported moderate to high levels of stigma (13). In another study, discrimination in Hiroshima Prefecture, Japan, among COVID-19 survivor participants reached 43.3% ($N = 140$) (27).

Current studies on the perception of stigma in COVID-19 survivors have found the following characteristics to correlate with stigma: (1) Age: Older COVID-19 survivors (≥60 years) experience higher social discrimination than COVID-19 survivors in other age groups (14). (2) Ethnicity: Ethnicity is one of the factors affecting the perceived stigma of COVID-19 survivors, with non-Arabs having a much higher perception of stigma than Arabs in Qatar (13). (3) Social support: Social support is a powerful weapon against stigma; thus, groups such as solitary populations and migrant workers have a higher risk of stigma and higher levels of COVID-19-related stigma perception (13). (4) Occupation: It has been shown that manual workers have higher levels of perceived stigma than those practicing professional occupations (13). However, health-care workers are a special case: COVID-19 survivor nurses have reportedly endured a higher degree of stigma (34). (5) Education level: Lower levels of education may result in higher perceived COVID-19 stigma (36). The more people lack understanding about how COVID-19 is spread, the more likely they are to experience COVID-19 stigma (14). Therefore, education can help prevent stigma by increasing awareness about the disease and reducing the likelihood of experiencing COVID-19 stigma (13).

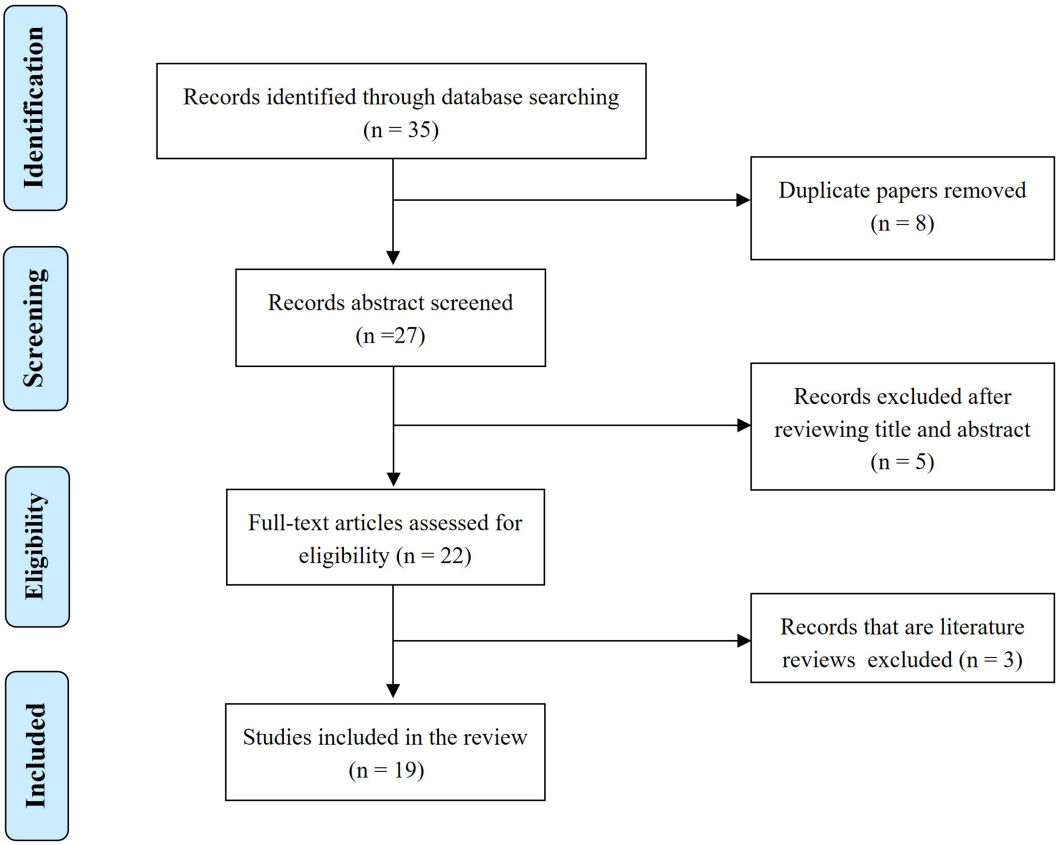

FIGURE 1
Flowchart of study selection progress.

TABLE 1 Basic information about the included articles.

No.	Study	Study design	Research time	Sample size	Study sites	Main outcome(s)
1	Halouani et al. (16)	Cross sectional	2021.03–2021.05	154	Tunisia	(A) An association between depression and stigma ($p = 0.002$) was found in COVID-19 survivors. (B) Anxiety, depression and post-traumatic stress disorder were independent of the severity of COVID-19.
2	Wahyuhadi et al. (25)	Cross sectional	2020.10–2020.12	547	East Java Province, Indonesia	(A) COVID-19 survivors experienced medium stigma in society and lower quality of life and mental health status. (B) Medium stigma was more likely to be related to quality of life and mental health than low stigma.
3	Fu et al. (26)	Cross sectional	2020.07–2020.09	199	Five cities in China (Wuhan, Shenzhen, Zhuhai, Dongguan and Nanning)	(A) Of all participants, 10.1% reported terrible/poor sleep quality compared to the time before COVID-19. (B) Stigma after recovery was associated with poor sleep quality among COVID-19 survivors, while social support was a protective factor.
4	Amir (6)	Qualitative research	2020.11	30	Kampala, Uganda	(A) COVID-19-related stigma is prevalent, and the most common form of stigma was social rejection and labeling. (B) COVID-19 survivors faced social rejection and community ostracism.
5	Alchawa et al. (13)	Cross sectional	2021.06–2021.08	404	Qatar	(A) More than a quarter of COVID-19 survivors in Qatar had moderate to high perceived stigma. (B) Significant association between perceived stigma and patients' ethnicity, educational status and type of occupation.
6	Yuan et al. (7)	Cross sectional	2020.05–2020.09	154	ChongQing, China	(A) COVID-19-related stigma is commonly experienced among COVID-19 survivors. (B) Appropriate psychological assistance, public education and anti-stigma campaigns and policies should be enforced to reduce COVID-19-related stigma.
7	Sahoo et al. (9)	Qualitative research	2020.01–2020.05	3	India	Mental health issues, including COVID-19-related stigma, would not have come to the forefront if mental health professionals were not involved in management.
8	Sugiyama et al. (27)	Cross sectional	2020.08–2021.03	140	Hiroshima Prefecture, Japan	(A) Experiences of stigma and discrimination were reported by 43.3% of participants. (B) Significant impacts of long COVID on health in local communities.
9	Yadav et al. (28)	Cross sectional	2020.10–2020.11	122	Delhi, India	(A) Statistically significant association between feeling ashamed and blaming themselves for COVID-19 ($p = 0.046$). (B) The stigma related to COVID-19 needs to be tackled with a multipronged strategy.
10	Atinga et al. (29)	Qualitative research	2020.03–2021.02	45	Greater Accra Region, Ghana	Everyday lived experiences of the participants were disrupted with acts of indirect stigmatization, direct stigmatization, barriers to realizing a full social life and discriminatory behaviors across socioecological structures.
11	Campo-Arias et al. (30)	Cross sectional	2020.10–2021.04	330	Santa Marta, Colombia	(A) Depression, insomnia and post-traumatic stress were significantly associated with the discrimination perceived by COVID-19 survivors. (B) Perceived discrimination is a social stressor that affects the psychological well-being of people recovered from COVID-19.

(Continued)

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TABLE 1 (Continued)

No.	Study	Study design	Research time	Sample size	Study sites	Main outcome(s)
12	Damant et al. (31)	Longitudinal Cohort	2021.05–2022.05	145	Canadian City of Edmonton, Alberta	(A) Total stigma score was positively correlated with symptoms, depression, anxiety, loneliness, reduced self-esteem, thoughts of self-harm, post-COVID functional status, frailty, EQ5D5L score and number of ED visits. (B) Total stigma score was negatively correlated with perceived social support, 6-min walk distance and EQ5D5L global rating.
13	Osei et al. (32)	Cross sectional	2020.10–2020.11	3,529	Ghana	Because of the relatively high proportion of poor knowledge and negative attitudes toward COVID-19, stigma and discriminatory tendencies were consequently high.
14	Iqbal et al. (33)	Cross sectional	2020.09–2020.12	158	Karachi, Pakistan	Long-COVID syndrome, including COVID-19-related stigma, is similar to the post-discharge manifestations of the survivors of prior pandemics (SARS and MERS).
15	Winugroho et al. (34)	Cross sectional	2020.12–2021.03	63	Central Java Province, Indonesia	Stigma is an important predictor that affects mental toughness and quality of life to increase immunity for nurses themselves.
16	Siregar and Purba (35)	Experiment research	–	25	Indonesia	There was no significant reduction in stigma after intergroup contact, for example, a video conference.
17	Adhikari et al. (8)	Cross sectional	2020.09–2021.01	303	18 districts located in 7 States in India	(A) Of the COVID-19 survivor participants, 38.6% reported experiencing severe stigma. (B) Study recommends the timely dissemination of accurate information to populations vulnerable to misinformation and psychosocial interventions for individuals affected by stigma.
18	Latha et al. (14)	Cross sectional	2020.10–2020.11	150	Visakhapatnam, India	Social discrimination among participants was greater with increased age, female gender, among educated people, in joint families, among married individuals, in upper social class and for those who had a long hospital stay; however, it was not significantly associated statistically.
19	Dar et al. (36)	Cross sectional	2020.04–2020.06	91	Kashmir, India	(A) High levels of enacted and externalized stigma among COVID-19 survivors. (B) Enacted stigma was greater among males and in those who were highly educated.

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3.2. Mechanisms causing stigma

It has been shown that the stigmatization of COVID-19 survivors stems from two main sources, namely enacted stigma and internalized stigma.

On the one hand, as far as enacted stigma is concerned, it mainly originates from the community. Recovered COVID-19 patients often suffer from stigmatization and discrimination, and their communities have an irrational fear of them (33). In a study involving 199 COVID-19 survivors, 30% of the participants confessed to having experienced rejection by their neighbors or community (26). Alchawa et al. (13) found that some workers in specific occupations that require contact with many people, such as grocery store clerks and delivery drivers, were more at risk for experiencing stigmatization; this is because they were accused of bringing disease into the community. There are also communities where elders pray for divine intervention and spiritual protection to help the community in the fight against COVID-19 when they believe that human power alone can no longer stop the spread of the virus; however, this can also increase stigma because once someone is infected with COVID-19, he is treated as an offender to the gods (29).

On the other hand, internalized stigma is also a source of stigmatization. In the context of a global outbreak of COVID-19, the fear of the virus devalues the social status of those associated with it. This phenomenon creates negative self-image of the prejudiced group, which triggers their internalized self-stigma. In Santa Marta, Colombia, 32.12% of COVID-19 survivors ($N = 330$) had high perceptions of stigma, which increased their risk of depression and insomnia (30). Almost all existing studies point out that stigma originates from fear. Suryandari (37) argued that the reason for COVID-19 stigma is because COVID-19 is a new disorder, and people become afraid of associating with other people because of their fear of the unknown. Due to the lack of knowledge about the new virus, people may misunderstand the infection, and some may even see it as a curse or sin (14).

3.3. The psychosocial impact of COVID-19 stigma on survivors and society

The COVID-19 pandemic triggers widespread stigma toward those who have contracted the virus or are associated with it, causing psychosocial problems and potential societal outbreaks. A number of studies have shown that stigma can put COVID-19 survivors under greater stress, which, in turn, can lead to many negative social consequences (16, 25, 31). It can be seen in various ways: (1) Once a generalized COVID-19-related stigma develops, it can lead to serious psychosocial problems and mental instability (29). High levels of perceived stigma can cause depression and insomnia in COVID-19 survivors (30). (2) Stigma is not only directed at COVID-19 survivors, but also at their family members, which can lead to self-blame and further jeopardize their psychological well-being (14). (3) Severe stigma may encourage people to avoid stigmatization by hiding the disease. This, in turn, will likely lead to a social outbreak of the virus (37). (4) In the long run, this may lead to social catastrophe. Stigmatization can undermine social cohesion and lead to the social ostracism and isolation of COVID-19 survivors (37).

3.4. Suggested responses to counter stigma

To support COVID-19 survivors in overcoming this crisis and prevent the emergence of larger social problems, existing research primarily proposes destigmatization pathways such as psychological counseling services, social support, and health education.

1. Psychological counseling services: Professional psychological help can be an effective response to mental health problems. From the beginning of discharge preparation, we should carry out actions to reduce the intrinsic stigma of COVID-19 survivors (30), where early psychological interventions can reduce the long-term adverse effects of mental illness due to stigma (38).
2. Social support: COVID-19 survivors are vulnerable when returning to their communities, as they face stigmatization (25). Therefore, the dissemination of this information in the community should be discouraged and community support should be provided (39). If COVID-19 survivors and their families are at risk of physical attacks in the community, policies and regulations to protect them should also be developed and improved (40). But simply encouraging intergroup contact and communication seems less effective in reducing stigma (35).
3. Health education: In the face of stigma, it is necessary to pay attention to social health education work. In the information age, appropriate and reliable ways to disseminate COVID-19-related information should be promoted (32). It is important to dispel the idea that COVID-19 survivors are still contagious after recovery (32, 33). Health education regarding COVID-19 can be carried out through various authoritative media channels such as public service announcements, newspapers and television programs.

4. Marxist criticism on stigmatization of COVID-19 survivors

Most current studies conceptualize the mechanisms underlying the stigmatization of COVID-19 survivors as a set of attributes of the individual, while the power inequality generated by class relations is somewhat neglected. Thus, Marxist analysis is introduced in this paper to reveal additional knowledge on social care policies learned from the stigmatization of COVID-19 survivors.

4.1. The complex nature of stigmatization beyond individual attributes

Stigmatization is a form of violence committed by people who tend to stigmatize against certain groups. Existing studies have identified some characteristics of stigmatized groups, such as manual workers and those with a low education level (13). However, studies on individuals with stigmatizing tendencies have not found specific characteristics. For instance, in a study by Osei et al. (32), some socio-demographic characteristics such as education, marital status,

employment and religion did not significantly predict the propensity to stigmatize COVID-19 survivors. This indicates that explaining stigma solely in terms of individual sociodemographic characteristics is not sufficient.

Although existing studies summarize the characteristics of stigmatized groups, these individual characteristics are only superficial features. Many risk factors, such as lower social support, lower-paid occupations, and lower levels of education, are commonly concentrated in certain groups. Therefore, the issue of stigmatization cannot be exclusively explained by individual factors. Instead, it is embedded in fundamental political, socioeconomic, and philosophical problems. To understand the mechanisms underlying stigmatization, it is necessary to introduce the perspective of social power and social relations. Marxism provides a framework that can effectively address this requirement. According to Marxist theory, public health and its related issues are products of capitalist domination and the reproduction of dominant class ideology (41, 42). Similarly, COVID-19-related stigma is not solely a medical issue; it is also about ideology and capital logic.

4.2. The influence of capitalist systems on the stigmatization of COVID-19 survivors

By applying Marxist criticism to the stigmatization of COVID-19 survivors, valuable insights can be gained into how this phenomenon is deeply entrenched in larger structures of power and exploitation. Specifically, Marxist analysis reveals how capitalist systems have played a significant role in perpetuating and exacerbating the stigmatization of COVID-19 survivors.

Firstly, capitalism increases the risk of spreading infectious diseases and stigma. Capitalism spreads the disease by impoverishing migrant health and blaming them, where territorial, political, judicial and economic expulsions are their means (43). Siu's study (44) of social and cultural values found that the vulnerability of some groups to stigma is reinforced under the capitalist ideology. It has also been shown that workers with the least power and resources are overlooked because they do not have easy access to infectious disease-related testing, and they are more often stigmatized (45). It is no wonder that Henderson (46) argued, "surely it is time the medical profession objected publicly and loudly to being manipulated by government and the corporate interests it transparently serves."

Secondly, capitalism has kidnapped science, which can no longer be truly objective or independent. As criticized by McClure et al. (47), in the context of COVID-19, epidemiology now focuses the obtention of viral infections on individual biology and behavior. However, this ignores the influential role of the occupational environment in the transmission of the virus and, to some extent, absolves industry of responsibility for worker safety. In addition, there are studies showing that public and political attitudes toward masks need to rely more on scientific evidence. Such evidence, in addition to including epidemiological and infectiological information, should also consider its social and personal significance; otherwise, it may harm the interests of marginalized groups (48, 49).

Thirdly, capitalists have used the pandemic in their interest, resulting in workers facing harsher living conditions and a higher risk of infection, which exacerbates their stigma. As noted by Link and Phelan (50), "stigma power" is a resource that exploits and suppresses others through stigma. Although this process may manifest itself in all aspects of society, it is more visible and easier to capture in the workplace. For example, one study from Visakhapatnam confirmed this phenomenon. Wage cuts, company firings for being deemed unproductive and more have been observed with some COVID-19 survivors (14). In addition, when it comes to hiring employees, some companies even see the economic turmoil as an opportunity to hire workers on unsafe contracts (51).

4.3. The vicious circle of stigma and social inequality

While existing studies focus mainly on the psychosocial impact of COVID-19 stigma on survivors and society, little attention has been paid to how this stigmatization reinforces capitalist inequality mechanisms (29, 31). A discussion of this topic is crucial, as the mechanism of capitalist inequality has a direct impact on the allocation of public health resources, the improvement of the social care system, and the health and dignity of economically and socially disadvantaged groups who are more susceptible to stigmatization during epidemics.

The reproduction of stigma and social inequality reinforces each other, particularly for marginalized groups that are often hardest hit by stigma due to weak health, poverty, and low education levels (13). Stigma becomes a separate force and resource for control, subjugation, and exploitation in the hands of power by creating a division between stigmatized and non-stigmatized individuals, reinforcing existing power structures and maintaining the status quo. Stigmatized individuals may be excluded from opportunities and kept in a state of subjugation and dependence, while power holders use pandemic fear to justify increased control and restrictions, further reinforcing their control. This vicious circle leads to the reproduction of poverty, deteriorating health, and social inequality, increasing the risk of stigmatization (14, 51). Thus, it seems that this vicious circle is one of the social mechanisms that create stigma. In conclusion, "market incentives in capitalist economies and public health requirements are contradictory" (41).

4.4. A Marxist approach to social care policy

The social care system is a critical component of our social infrastructure, and the pandemic has highlighted the cost of neglecting it. Presently, social care policies that address stigma mostly focus on the healthcare sector, such as promoting public health knowledge, strengthening the psychological resilience of COVID-19 survivors, and correcting attitudes toward the virus (14, 32, 40). However, research has suggested that social support is necessary to eradicate stigma, but it has not yet revealed the social mechanisms of stigma or how to eliminate it from the perspective of social power inequality (25, 39).

Stigmatizing COVID-19 survivors is not just a problem of health information asymmetry and fear caused by ignorance. Dealing with this stigma requires more than avoiding the disclosure of private information or using the correct terminology (26, 28, 29). It is crucial to recognize that the health field is not the only component of the social care system.

Capital's profit motive may undermine healthcare systems by misallocating medical resources (46). Therefore, it is essential to establish better social care policies to counteract exploitation and oppression under power inequalities. If social care policies do not address the root causes of COVID-19-related stigma, such as the social determinants of marginalized people facing economic instability, they will continue to suffer from stigmatization, especially during times of crisis (52).

Firstly, Respect for all jobs, including low-skill and low-wage jobs, is crucial. These jobs often involve manual labor that requires contact with many people and provides limited social support and avenues of vocalization. Therefore, those in these jobs who become infected with COVID-19 are vulnerable to stigmatization (13), as they are allocated fewer social resources in the existing system. As a result, they may face more severe mental health problems and stress. However, the division of labor contributes to societal efficiency and low-skill jobs play an important role in society, particularly during an epidemic. As noted by International Labor Organization (ILO) (53), the COVID-19 pandemic may facilitate the erosion of the high skill/low skill distinction and encourage a re-evaluation of the socio-economic worth of certain occupations.

Secondly, Strengthening the power of trade unions across various industries can contribute to social care, especially in light of the deep-seated inequalities revealed by the COVID-19 crisis, particularly in the social care sector. From a trade union perspective, investing in workers in healthcare and informal sectors is crucial. Studies have shown that informal healthcare and migrant workers are stigmatized and at-risk groups, facing low formalization, wages, and unstable work hours (13, 54). These marginalized groups face economic instability, and given their tendency to minimize self-expression and avoid disclosing their psychological problems (55), their stigmatization problems are likely underestimated. They require union protection. Thus, highlighted, Workers organizations should regard Covid-19 as a wake-up call, a wake-up call for contributing to building forward better together; and the achievements during the crisis should serve as a steppingstone for a recovery for all, including workers in the informal economy (53).

Thirdly, we should aim to improve the social care system through tax system reform. Despite the fact that the average worker has experienced the longest pay squeeze in living memory over the past decade, total wealth has been growing in an unequal manner (56). Therefore, capitalists or the wealthy should pay their fair share to fix our social care system. In the healthcare industry, for example, studies have shown that with increased social support, the resilience and stress tolerance of healthcare workers can increase (34). We might start by raising the pay of healthcare workers and reforming the tax system and then gradually expand the reforms to create a better social care system.

5. Discussion

5.1. Main findings from Marxist criticism appraisal on overall literature review

The current study on the stigmatization of COVID-19 survivors has yielded the following key insights. Older age, ethnicity, lack of social support, manual occupation, and lower education levels are associated with higher levels of COVID-19 stigma perception. COVID-19 stigma is mainly thought to stem from enacted stigma (coming from the community) and internalized stigma (negative self-image of the prejudiced group triggered by the devaluation of social status). Considering that stigma can put COVID-19 survivors under greater stress, leading to negative social consequences such as isolation, avoidance, discrimination, and potential societal outbreaks, prompt responses are suggested to counter the stigma, such as psychological counseling services, social support, and health education.

Nonetheless, the discrimination against COVID-19 survivors cannot be solely explained by individual factors. Instead, it is rooted in underlying political, economic, and philosophical issues. In this paper, Marxist criticism is concerned with power dynamics and how they shape the relationships between individuals and groups, during the stigmatization of COVID-19 survivors. Additionally, we look at how the stigmatization of COVID-19 survivors is linked to broader issues of inequality and exploitation. By examining the economic, social, and political structures that underlie this phenomenon, we can identify the root causes of stigmatization and work toward creating a more just and equitable society.

Overall, capitalist systems have played a significant role in the stigmatization of COVID-19 survivors. Their emphasis on individualism, fear, and profit has contributed to a culture of blame and stigma, with COVID-19 survivors being labeled as irresponsible, a threat to economic stability, or even morally deficient. As humans will always coexist with viruses and continue to navigate past and future pandemics, it is essential to recognize and address the ways in which capitalist systems can perpetuate and exacerbate social inequalities and stigmatization. Stigma reinforces the mechanisms of capitalist inequality, particularly for marginalized groups who are often the most adversely affected by discrimination due to their poor health, poverty, and limited education levels. This perpetuates a destructive cycle of stigma and social inequality that directly affects public health resources, the enhancement of social welfare systems, and the well-being and dignity of economically and socially underprivileged communities.

5.2. Advantages and limitations of Marxist criticism

Marxist criticism is an analytical approach that can explain how economic structures, power relations, and political forces contribute to the stigmatization of certain groups. However, it is essential to recognize the limitations of the Marxist perspective when it comes to understanding COVID-19-related stigma fully.

On the one hand, Marxist criticism offers significant analytical advantages. First, it enables the elucidation of concerning trends in public health, such as privatized health economies. The power of the upper class and the political economy determinants of social care. This allows for a better investigation and interpretation of the mechanisms underlying COVID-19-related stigma. Second, Marxist criticism believes in our capacity for change and defends indispensable social values, such as creating an equitable society by ending exploitation. Finally, Marxist criticism is a call for engagement to protect these values by deepening opportunities for public participation in shaping collective choices.

On the other hand, it is clear from the above analysis that the Marxist perspective is not a panacea. Although it can explain part of the social mechanisms that shape stigma, there are also aspects that it cannot respond to. For example, in Latha et al.'s study (14), it was found that older people were more likely to be stigmatized than other age groups. In fact, age should indeed be considered as an independent, micro-level predictor of having a risk of being stigmatized. Older

individuals are more likely to be stigmatized, and age is associated with factors such as poor physical fitness and a weak immune system. Although Marxists believe that attitudes to old age are influenced by capitalism, they cannot deny that aging is an independent risk factor for health at the medical level (57). In this case, Marxism cannot completely replace the perspective of individual attribute analysis.

5.3. Research outlook on lessons from the stigma of COVID-19 survivors

To gain a more objective and comprehensive understanding of stigmatization, an integrated and pluralistic perspective is necessary. Instead of portraying stigmatized groups as limited in terms of individual attributes, the Marxist analytical perspective can enrich the study and explore the social mechanisms of stigma formation from a more macroscopic view. By doing so, researchers can contribute to the establishment of a comprehensive, scientific, and dimensional social care system.

Future research can significantly advance the study of the stigma of COVID-19 survivors by integrating the perspective of Marxism. Specifically, researchers could investigate how capitalist systems perpetuate and exacerbate social inequalities and stigmatization, and how these systems impact the distribution of resources and the well-being of marginalized communities. Additionally, researchers could explore the intersectionality of the stigmatization of COVID-19 survivors with other forms of oppression, such as racism, ableism, and homophobia. By adopting an intersectional approach, researchers can identify the unique challenges that certain groups face and develop targeted interventions to address these issues. Finally, future research can also explore the potential for collective action and social movements to challenge the stigmatization of COVID-19 survivors. Marxist theory emphasizes the importance of collective action and solidarity in challenging power structures and promoting social change. Therefore, research can examine how social movements can challenge the stigmatization of COVID-19 survivors and how this relates to broader struggles for social justice.

6. Conclusion

The stigmatization of COVID-19 survivors results from social power inequality, yet current research focuses on individual attributes as the mechanisms of stigma. A Marxist analysis can help expose how material conditions and economic practices shape the dominant ideologies surrounding stigmatization. The goal of this critical appraisal is to identify ways to end the stigma surrounding health-related issues. Current studies limit the contributors to social care to public health policymakers, medical departments, nursing homes, and communities, neglecting the roles and responsibilities of other subjects in social care. From a Marxist class analysis perspective, the responsible subject of social care should not be limited to the traditional subject. The function of trade unions and tax system reform in fixing our social care system should also be taken into consideration. Future research can advance our understanding of COVID-19 survivor stigma and social care reform by highlighting systemic factors that contribute to stigma and identifying avenues for collective action and change. Overall, the creation of a social care policy system is complex, impacted by numerous social factors, and should not only be studied in the field of public health. An interdisciplinary approach will be beneficial in future efforts to build the social care policy system.

Author contributions

J-LL and Y-KW worked together to conceptualize the research questions and prepare the research protocol, drafted the manuscript, and reviewed and edited the manuscript. All authors contributed to the article and approved the submitted version.

Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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Evaluation of the impact of the COVID-19 pandemic on health service utilization in China: A study using auto-regressive integrated moving average model

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Background: The outbreak of COVID-19 in early 2020 presented a major challenge to the healthcare system in China. This study aimed to quantitatively evaluate the impact of COVID-19 on health services utilization in China in 2020.

Methods: Health service-related data for this study were extracted from the China Health Statistical Yearbook. The Auto-Regressive Integrated Moving Average model (ARIMA) was used to forecast the data for the year 2020 based on trends observed between 2010 and 2019. The differences between the actual 2020 values reported in the statistical yearbook and the forecast values from the ARIMA model were used to assess the impact of COVID-19 on health services utilization.

Results: In 2020, the number of admissions and outpatient visits in China declined by 17.74 and 14.37%, respectively, compared to the ARIMA model's forecast values. Notably, public hospitals experienced the largest decrease in outpatient visits and admissions, of 18.55 and 19.64%, respectively. Among all departments, the pediatrics department had the greatest decrease in outpatient visits (35.15%). Regarding geographical distribution, Beijing and Heilongjiang were the regions most affected by the decline in outpatient visits (29.96%) and admissions (43.20%) respectively.

Conclusion: The study's findings suggest that during the first year of the COVID-19 pandemic, one in seven outpatient services and one in six admissions were affected in China. Therefore, there is an urgent need to establish a green channel for seeking medical treatment without spatial and institutional barriers during epidemic prevention and control periods.

KEYWORDS

public emergencies, emergency management, health services access, forecast model, health policy

1. Introduction

At the close of 2019, coronavirus disease 2019 (COVID-19), a severe infectious disease, rapidly disseminated to numerous countries worldwide within a few months. The outbreak brought health systems, education, entertainment, commerce, tourism, and manufacturing industries globally to a near standstill (1). As of 17:00 on March 7, 2023, Beijing time, the novel coronavirus has

undergone several rounds of mutations and has caused 758,390,564 infections and 6,859,093 deaths worldwide. In the early stages of the outbreak, limited information on the virus' pathogenesis and mode of transmission resulted in high infection rates and direct mortality (2, 3). On January 30, 2020, the World Health Organization (WHO) declared that the COVID-19 a public health emergency of international concern. Subsequently, COVID-19 prevention and control measures, such as social distancing, personal protective equipment use, and self-isolation were significantly upgraded (4).

COVID-19 was first reported in Wuhan, and it had spread to all the 31 provinces of China by the end of January 2020 (5). To prevent the further spread of the pandemic, the provinces of mainland China quickly launched the highest level of response (6), including large-scale isolation of infected individuals or those at risk of infection, suspension of production and commercial activities in some areas, closure of some non-communicable disease hospitals and community hospitals, and restriction of non-essential social activities (7). Although these measures quickly reduced the number of infections at the social level to zero, they also generated spatial and institutional barriers that constrained public access to health services to some extent, especially during the pandemic. Moreover, the COVID-19 outbreak also disrupted other health resources, resulting in the closure of some non-emergency departments in China (8). Reduced access to health services, including essential health services, is one of the harmful manifestations of the prolonged COVID-19 epidemic and needs to be quantified to assess its objective impact. Several countries have recently reported quantitative data on the pandemic's impact on health service utilization. For instance, during the first wave of the pandemic, health service utilization in the UK dropped by 70% (9). In Australia, manual therapy service utilization by private agencies decreased by approximately 7% during the first half of 2020 (10). However, there is a lack of national-level quantitative studies on this topic in China. Therefore, this study uses long-term data based on the Auto Regressive Integrated Moving Average model (ARIMA) to predict theoretical health service utilization data in 2020 if this outbreak had not occurred. The differences between the predicted and actual values in 2020 are then compared to quantify the impact of COVID-19 on health services utilization.

2. Methods

2.1. Data sources and study design

The China Health (Health and Family Planning) Statistical Yearbook is a comprehensive national-level health service statistics manual edited by the National Health (Health and Family Planning) Commission. Each edition of the yearbook presents China's health-related data for the preceding year, encompassing data on health resource allocation, health expenditure, health service utilization, and population health-related indicators. Notably, the data covered 31 provinces in mainland China, excluding Hong Kong, Macau, and Taiwan, due to inconsistent statistical standards. In this study, we obtained data from the yearbook spanning the period 2010 and 2020. Target data from 2010 to 2019 were input into the ARIMA forecast model to predict the 2020 data in the absence of the outbreak. The data from the Statistical Yearbook for 2020 are after the impact of the pandemic. To roughly estimate the impact of the pandemic on health service utilization, we calculated the difference between the actual and forecast values for 2020. To clarify the characteristics of the impact, we conducted comparisons of data across different types of hospitals, 21 clinical departments, and 31 provinces. For simplicity, "province" here refers specifically to the original province (such as Hubei), municipality (such as Tianjin), and autonomous region (such as Xinjiang). The data were organized chronologically to establish a group of time series.

2.2. Auto-regressive integrated moving average model

The ARIMA model, was originally developed by Box and Jenkins as a forecasting tool for economic variables, is also known as the Box-Jenkins method (11). The first half of the statistical analysis of this study, a time series analysis was conducted to predict future values of the series. ARIMA is one of the most popular linear models for forecasting time series due to its ability to account for changing trends, periodic variations, and stochastic perturbations in time series. Given that the change in health service utilization is driven by multiple factors, the ARIMA model is considered to be the most appropriate model under existing conditions.

The ARIMA model is typically specified as a simple ARIMA (p, d, q) model, a seasonal ARIMA (P, D, Q) S model, and a seasonal-product ARIMA (p, d, q) (P, D, Q) S model, where p, d, q and P, D, Q are the continuous and seasonal order of autoregression, degree of difference, and order of moving average, respectively (12). As this study did not involve seasonal data, only the simple ARIMA model was utilized for the statistical analysis.

2.3. Models construction and selection

The ARIMA model is developed through four synergistic steps, which include time series stationary, model identification, parameter estimation, and diagnostic checking (13). Initially, ARIMA models necessitate a stationary time series. and the Augmented Dickey-Fuller (ADF) unit-root test can determine whether a time series is stationary. The parameters of the ARIMA model were estimated using autocorrelation function (ACF) plot and partial autocorrelation (PACF) plot, and the "auto.arima()" command in R software was employed to promptly identify the most suitable model. Finally, the Ljung-Box test was performed to confirm that temporal autocorrelation no longer existed in the model residuals (13, 14).

The statistical appropriateness and predictive accuracy of the selected models were assessed using Mean Absolute Percentage Error (MAPE), whereby lower values indicated a better fit of the data (15) (13). MAPE is represented by equation (1) below. ARIMA model selection and MAPE results for all time-series analyzes are elaborated in Supplementary Table S1.

$$\mathrm{MAPE} = \frac{1}{n}\sum_{i=1}^{n}\left|\frac{e_i}{x_i}\right| \quad (1)$$

Where n is the number of time points, x_i is the actual value at time point i, and e_i is the difference between the actual and forecast values.

2.4. Data analysis

Microsoft Excel 2016 was used for data extraction and initial statistical analysis. ARIMA models were developed using the forecast package and tseries package in R software 4.1.2 to forecast 2020 values based on the existing time series (2010–2019). The output of this model included the forecast value and its 95% confidence interval (95%CI). The differences between the forecast values and the actual values in 2020 and the percentage changes (2) were derived to indicate the impact of COVID-19 on health service utilization.

$$\text{Percentage change} = \frac{(V_{forecast} - V_{actual}) \times 100}{V_{forecast}} \quad (2)$$

Where $V_{forecast}$ is the forecast value for 2020, V_{actual} is the actual value for 2020.

3. Results

3.1. Overall results and different types of hospitals

In 2020, the total number of outpatient visits and admissions in China were 7.74 billion and 2.30 billion, respectively. Between 2010 and 2019, there was an increase in the number of admissions and outpatient visits in all types of hospitals, regions, and almost all departments (except for the admissions in the prevention health department). Overall, the forecast values of admissions and inpatient visits in 2020 were 9.04 billion and 2.80 billion, respectively, representing a total decrease of 1.30 billion outpatient visits and 500 million admissions during the year, corresponding to percentage changes of 14.37 and 17.74%, respectively (Figure 1).

In China, public hospitals remain the primary providers of health service and were the most impacted by the pandemic, with a percentage change of 18.55% (635.78 million) outpatient visits and 19.64% (36.25 million) admissions in 2020. Conversely, admissions in private hospitals and outpatient visits in primary hospitals were relatively less impacted, with percentage changes of 12.47% (539.28 million) and 11.58% (50,100), respectively. Traditional Chinese medicine (TCM) hospitals had smaller reductions in outpatient visits and admissions compared with comprehensive hospitals, with percentage changes of 15.68% versus 18.29 and 16.69% versus 18.97%, respectively (See Figure 2 for more results).

3.2. Results between different hospital departments

Figure 3 displays the outpatient service utilization for different departments. Except for the preventive medicine department, which had a higher than predicted value of outpatient visits in 2020, all other departments had fewer numbers of outpatient visits by 321.83 thousand to 208.69 million in 2020. Among them, internal medicine, pediatrics, and general medicine departments had the largest reductions, of 208.69 million, 198.99 million, and 136.85 million, respectively. Pediatrics, otolaryngology, and dermatology were the top three departments based on percentage change, with reductions of 35.15, 23.34, and 20.64%, respectively. Conversely, the change rates in oncology, infectious diseases, and preventive health care were 4.77, 1.93%, and-11.97%, respectively, indicating that they were less affected by the pandemic.

Figure 4 illustrates the impact of the pandemic on hospital admissions in different departments. The actual number of admissions in all departments was lower than predicted, with reductions ranging from 10.20 thousand to 14.50 million. Among them, internal medicine, pediatrics, and surgery were the three most affected departments, with reductions of 14.50 million, 8.70 million, and 6.50 million, respectively. However, the internal medicine and the surgery departments had the lowest percentage changes among those of all departments, at 5.21 and 9.72%, respectively. The top three departments with the highest percentage changes were occupational medicine, 33.99%; psychiatry, 31.46%; and general medicine, 26.27%. Additionally, the infectious diseases department, which is directly related to COVID-19, also had a reduction of 1.1841 million, with a percentage change of 9.89%.

3.3. Results between different regions

The findings indicate that the actual number of outpatient visits in all provinces in 2020 was lower than estimated, with reductions ranging from 809.90 thousand to 197.59 million and a percentage change of 0.59 to 29.96% (Supplementary Table S2). Beijing, Heilongjiang, Tianjin, Guangdong, and Liaoning had percentage changes of more than one-fifth, at 29.96, 25.20, 22.23, 21.38, and 20.78%, respectively. In contrast, the impact of the epidemic on outpatient visits in Anhui, Hainan, and Tibet were relatively less, with percentage changes of 0.59, 2.03, and 4.47%, respectively (Figure 5A).

In Figure 5B, the number of admissions in the provinces decreased by between 106,710 and 4,226,794, except for Tibet, whose number of admissions increased by 25.49 thousand. The percentage changes in China revealed that the distribution characteristics decreased from north to south and from east to west. The number of admissions in Heilongjiang (43.20%) decreased by nearly half, and that in Beijing (37.69%) decreased by more than a third. In addition, the percentage changes in hospital admissions in Tianjin (27.04%), Jilin (26.90%), Hubei (29.18%), and Xinjiang (29.07%) were over a quarter. In contrast, the number of admissions in Tibet increased by 8.34%.

3.4. Results of model selection and MAPE

Supplementary Table S1 shows the selection of ARIMA models and MAPE values for each time series. The results indicate that the ARIMA (0,1,0) model is the most appropriate for the majority of health service utilization data sets, implying that only one differencing is required to render the time series stationary. Moreover, the MAPE values for the prediction models for total admission and outpatient service utilization are found to be 1.68 and 1.78%, respectively. Additionally, the MAPE ranges of the ARIMA prediction models for different types of hospitals, departments and regions are 1.36–3.66%, 0.76–10.47% and 0.95–10.38%, respectively. See Supplementary Table S1 for other details.

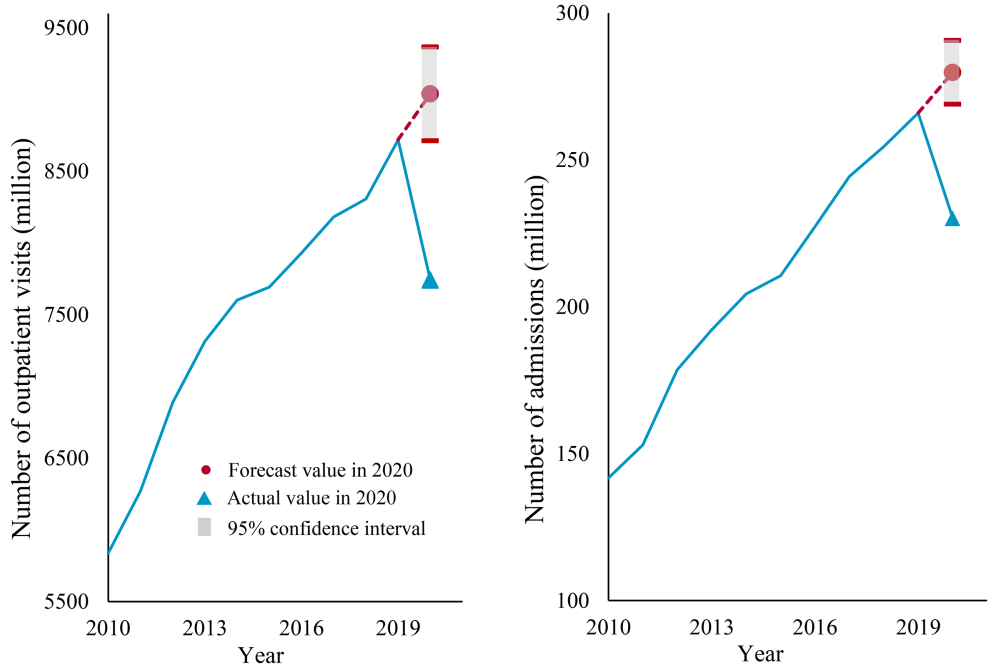

FIGURE 1
Actual and forecast values of overall health service utilization in 2020.

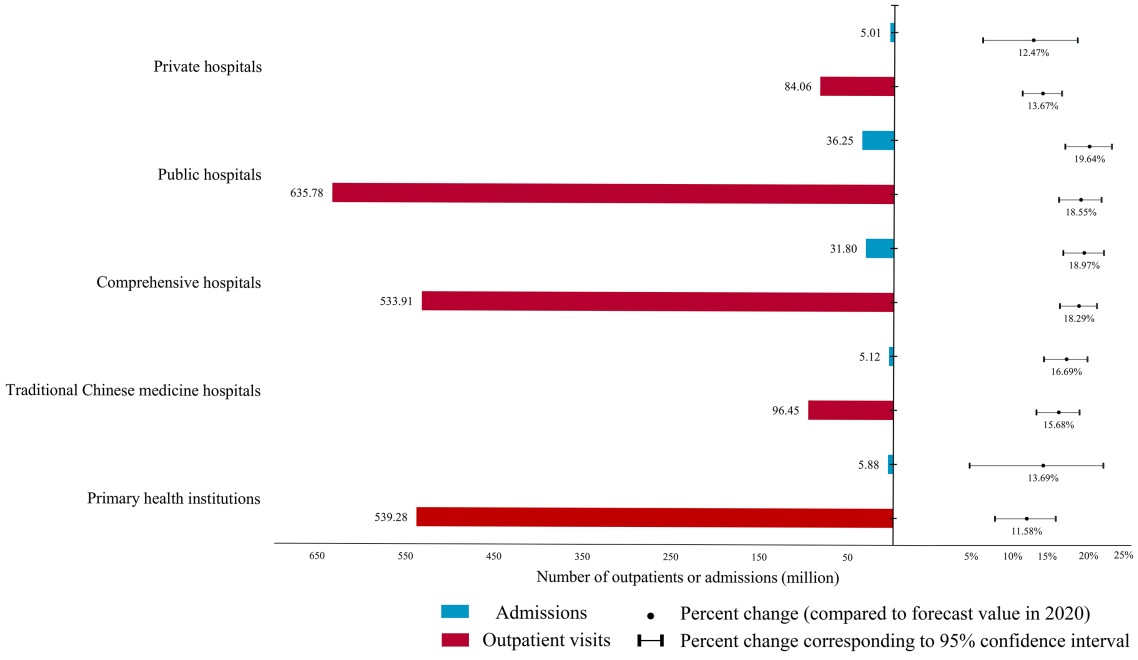

FIGURE 2
The difference between the forecast and actual health service utilization in different types of hospitals in 2020 and its percentage change.

4. Discussions

The COVID-19 pandemic has wrought significant disruption to the normal social order worldwide in its first year. To our knowledge, this study represents the first attempt to investigate the impact of the first year of the pandemic on health service utilization in China, based on real-world data. The study reveals several key findings. First, the number of outpatient visits and admissions in China decreased by 14.37 and 17.34%, respectively, in 2020. Second, health service utilization was adversely impacted to varying degrees across virtually all types of hospitals, departments, and regions. Third, there was a reduction of more than a third outpatient visits in the pediatrics

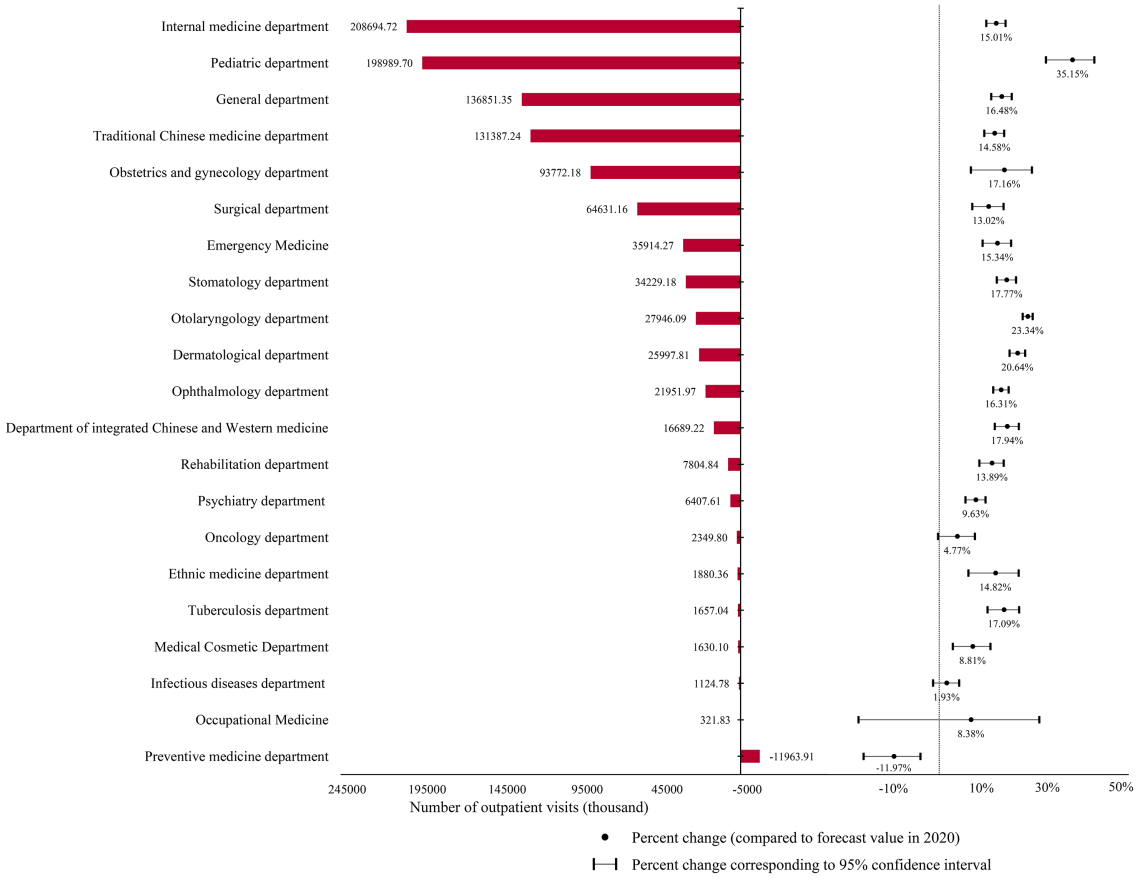

FIGURE 3
The difference between the predicted and actual values of outpatient visits in different hospital departments in 2020 and the percentage change in it.

department and admissions in the occupational medicine department. Fourth, Beijing and Northeast China were among the regions whose health service utilization was most affected. These results provide quantitative evidence of the pandemic's devastating social impact.

Comparing our findings to those reported in other countries can shed light on the global scope and patterns of pandemic-related disruptions in health service utilization. A growing body of literature has documented the negative effects of the COVID-19 pandemic on health services access and utilization in various settings. For example, a recent study from UK found that health service utilization decreased by 70% and respiratory system disease treatment services by 42% during the first wave of the pandemic. (9) Another study in Yemen reported a 10% reduction in surgery and a 4% decrease in medical consultation during the early phase of the pandemic in 2020 (16). Similar trends were observed in other countries, such as Armenia (17), Iran (18), and Italy (19). However, the magnitude and duration of the declines varied across countries and healthcare sectors, reflecting differences in the pandemic's severity, public health response, healthcare system capacity, and patient behavior. By highlighting the similarities and differences between our results and those of other countries, we can better understand the multifaceted challenges and opportunities for healthcare delivery and policy during and beyond the pandemic.

In China, the impact of the COVID-19 epidemic on the utilization of health services are multifaceted and can be attributed to two dimensions. First, the direct impact of the epidemic. At the onset of the outbreak, the lack of knowledge about the transmission and virulence of the novel coronavirus resulted in the destruction of the local health service system. Consequently, the government dispatched a large number of health staff from hospitals across the country to assist areas with uncontrolled outbreaks (20). During the normalization stage, there were small and controllable outbreaks in some cities. Doctors in hospitals were tasked with collecting sample from residents for nucleic acid analysis. Moreover, the high risk of infection also led to doctors being isolated at home or in designated facilities thereby reducing the provision of health services in the short term. Second, epidemic prevention and control policies have also contributed to the challenges in accessing health services. China is one of the few countries in the world that implemented a "zero-COVID" policy (referring to the government's efforts to stop the spread of the epidemic so that there are no COVID-19 patients at the social level) (21). which restricts non-essential outdoor activities for residents in endemic areas for at least 2 weeks to contain the spread of the epidemic (22). Meanwhile, primary health institutions were closed, and only one outpatient department handling patients with fever was left to serve COVID-19 patients and suspects (23). There are even large hospitals that temporarily closed outpatient services to prevent nosocomial infections. These policies created spatial barriers to local patients accessing health services. To address the

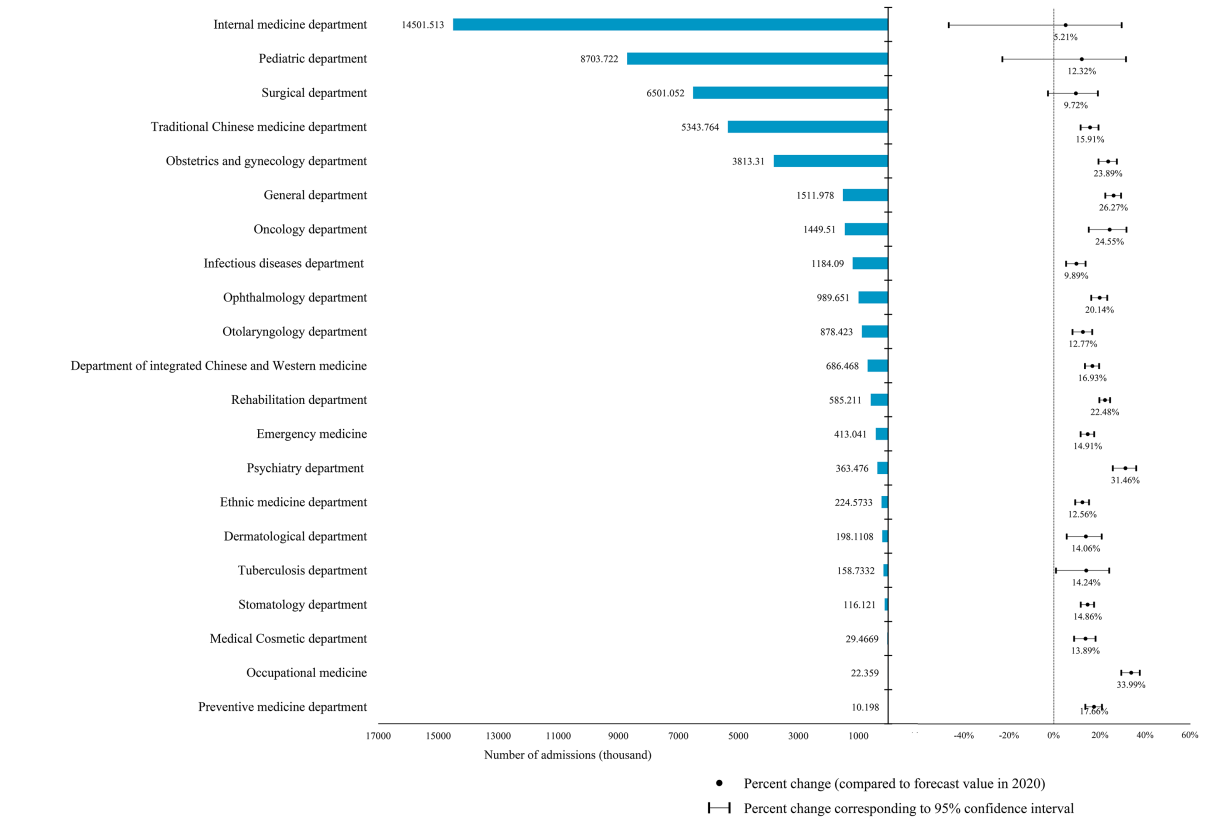

FIGURE 4
The difference between the predicted and actual values of admissions in different hospital departments in 2020 and the percentage change in it.

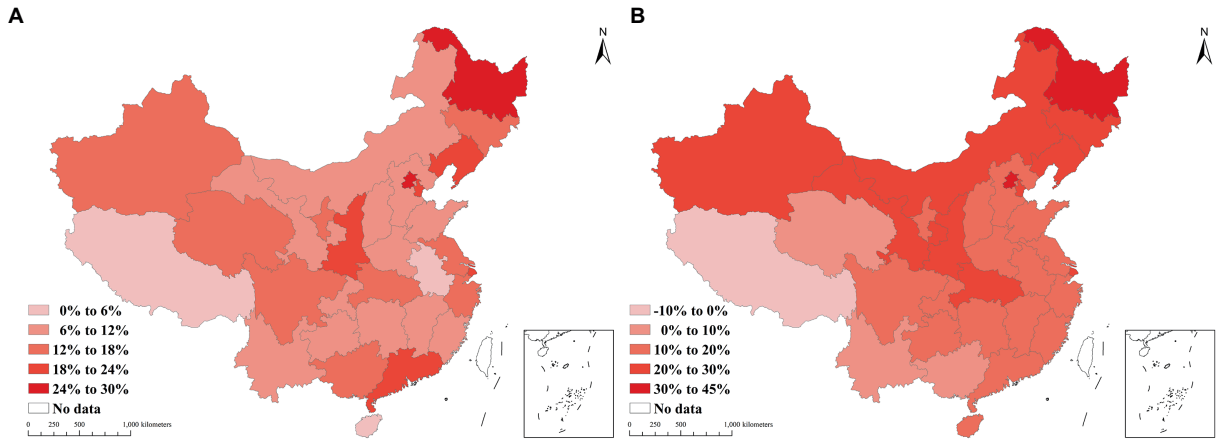

FIGURE 5
The percent change in health service utilization by province in 2020, **(A)** the percentage change in outpatient visits, **(B)** the percentage change in admissions.

spatial inaccessibility of health services in endemic areas, some hospitals have offered telemedicine services to patients (24, 25). Nevertheless, online medical services lack objective diagnostic evidence (such as biochemical tests), limiting the medical assistance that can be provided to patients.

The impact of the COVID-19 pandemic on health services utilization varies across hospital departments and regions. The pediatrics department experienced the greatest decline in outpatient visits, losing over one-third of its patients in 2020, ranking first among all departments. Pediatrics is one of the busiest medical specialties in China, and previous studies have reported that pediatricians work more intensively than non-pediatricians (26). Consequently, the absence of pediatricians due to the epidemic had a far greater impact on outpatient services utilization than the

absence of other specialists. Moreover, fears of nosocomial infections and complicated procedures (e.g., timely negative nucleic acid test report of the coronavirus as a pass to enter the hospital) during the pandemic made parents to delay hospital visits for their children with non-emergency conditions. However, it is worth mentioning that the number of outpatient visits only increased in the preventive health department. One possible explanation is that the COVID-19 outbreak promoted the demand for services such as infectious disease prevention, vaccination, and health education in this department.

Beijing, as the capital of China, has an abundance of health resources and attracts countless patients to seek medical treatment annually (27). However, travel restrictions between different regions during the early stages of the pandemic resulted in fewer out-of-town patients migrating to Beijing for medical treatment, making it one of the cities most affected by the pandemic's impact on health service utilization. Additionally, travel restrictions during the Spring Festival prevented migrant workers from leaving their hometowns, leading to a relatively low decline in health services in labor-exporting provinces such as Anhui Province was relatively low. The differences in the pandemic's impact on health service utilization across regions may be related to local epidemic prevention and control measures. For instance, Tibet, which had only one COVID-19 case in 2020, had a larger than predicted number of admissions (8.34%), while Heilongjiang, which had more than 1,000 cumulative cases in the same year, experienced the greatest decline in admissions (43.20%) (28).

The health service utilizations (unoccurring health service demands) affected by COVID-19 are objectively divided into necessary and non-necessary. For necessary health services, especially emergency services, need to be paid attention to and addressed. At the policy level, several recommendations can be made to address this issue. Firstly, governments should establish a system of barrier-free access to health services, including both institutional and spatial accessibility, in preparation for potential pandemics. Secondly, doctors and nurses, especially pediatricians, should not be deployed to participate in sample collection for nucleic acid analysis unless necessary, so that they can focus on their primary healthcare duties. Thirdly, telemedicine should be taken full advantage of to improve the spatial accessibility of health services. Lastly, primary healthcare institutions should not be closed during epidemics, as this can cause further strain on the healthcare system.

Several limitations must be considered when interpreting our findings. First, China launched healthcare reforms in 2009, and since then has issued a series of health policies (29). These policies may have influenced the consumption and provision of health services, and thus may have affected the accuracy of our ARIMA model predictions. Second, the interpretation of our results is based on the reports of previous studies and empirical reasoning; there may be some bias, and care should be taken when interpreting our findings. Third, our study did not consider the impact of health service utilization in Fangcang hospitals, where COVID-19 patients were centrally isolated and treated. Fourth, the accuracy of the predicted results is related to the model's MAPE value, and researchers referring to our findings should take these into consideration. Fifth, we relied mainly on official data sources that may not fully reflect the real-world situation. Lastly, due to the time lag of official data publication, this study only examined the impact of the 2020 pandemic on health service utilization.

Based on the findings and limitations of this study, we suggest several directions for future research. First, future research should examine the effects of COVID-19 on the quality of care and health outcomes of patients who utilized health services during the pandemic. This would provide a comprehensive assessment of how the pandemic impacted the quality and effectiveness of health service delivery and whether it created any gaps or disparities in care. Second, future research should investigate the determinants and patterns of health service utilization among specific populations, such as elderly people or people with chronic conditions. These populations may have distinct needs and preferences for health services and may face different barriers and risks during the pandemic. This would enhance our understanding of their experiences and expectations for health services and inform the development of tailored interventions to improve their access and satisfaction.

5. Conclusion

The study quantifies the impact of COVID-19 on health services utilization in China. In 2020, the actual utilization of admissions and outpatient services decreased by about one-sixth and one-seventh, respectively, as compared to the values predicted by the ARIMA model. The reasons for the impact on health service utilization are multifaceted, encompassing the direct effects of COVID-19 and its prevention and control policies. In the future, governments must establish a mechanism to enhance access to health resources for patients in need of health services (especially emergencies) during infectious disease pandemics.

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 authors.

Author contributions

RX: literature search, data collection and analysis, and manuscript preparation. CX: study design and guidance and financial support. TM: data collection and analysis. YL: data presentation and manuscript revision. YY: literature search and manuscript preparation. LW: figure making, data collection, and analysis. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2023.1114085/full#supplementary-material

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Comparative analysis of prevention and control measures toward COVID-19 epidemic between Shanghai and Beijing

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Purpose: By serving and providing a guide for other regional places, this study aims to advance and guide the epidemic prevention and control methods, and practices and strengthen people's ability to respond to COVID-19 and other future potential public health risks.

Design/methodology/approach: A comparative analysis was conducted that the COVID-19 epidemic development trend and prevention and control effects both in Beijing and Shanghai. In fact, regarding the COVID-19 policy and strategic areas, the differences between governmental, social, and professional management were discussed and explored. To prevent and be ready for potential pandemics, experience and knowledge were used and summarized.

Findings: The strong attack of the Omicron variant in early 2022 has posed challenges to epidemic prevention and control practices in many Chinese cities. Shanghai, which had achieved relatively good performance in the fight against the epidemic, has exposed limitations in its epidemic prevention and control system in the face of Omicron. In fact, the city of Beijing has undertaken prompt and severe lockdown measures and achieved rather good results in epidemic prevention and control because of learning from Shanghai's experience and lessons; adhering to the overall concept of "dynamic clearing," implementing precise prevention and monitoring, enhancing community control, and making emergency plans and preparations. All these actions and measures are still essential in the shift from pandemic response to pandemic control.

Research limitations/implications: Different places have introduced different urgent policies to control the spread of the pandemic. Strategies to control COVID-19 have often been based on preliminary and limited data and have tended to be slow to evolve as new evidence emerges. Hence, the effects of these anti-epidemic policies need to be further tested.

KEYWORDS

COVID-19 epidemic, omicron, epidemic prevention and control, comparative analysis, prevention and control measures

1. Introduction

It has been two and a half years since the outbreak of COVID-19 at the end of 2019, and it is still prevalent world widely. In China, prevention and control of the epidemic has always been under pressure (1, 2). Shanghai is the most populous urban area in China with 40 million inhabitants living in the Shanghai metropolitan area and the only city in East Asia with a GDP greater than its

corresponding capital. With the characteristics of a large population, a high degree of agglomeration, growing social mobility, and frequent export and import, the prevention and control of the epidemic are under great pressure from both inside and outside (3). As of December 31, 2021, Shanghai has effectively and accurately balanced the relationship between the fight against the COVID-19 epidemic, economic and social development, and normal life and production. Pursuing the concept of "balanced anti-epidemic" and adopting the prevention and control model of "professional governance, precise prevention and control, and lean execution." The risk and cost of the epidemic have been relatively reduced (4). However, with the latest severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) variant Omicron (B.1.1.529) has been revealed that it is over ten times more contagious than the original virus or about twice as infectious as the Delta variant. The "balanced anti-epidemic" policy shows its limitations. At the beginning of March 2022, Shanghai experienced the largest cluster of infections since 2020, which lasted for nearly four months. Subsequently, at the end of April, a cluster of outbreaks caused by Omicron also broke out in Beijing, but the number of infections was significantly reduced. These epidemic clusters have highlighted several issues and gaps in China's present epidemic prevention and control measures. In many cases, fragmentation between public health on the one hand, and political and economic priorities on the other, has led to confusion in reaching policy decisions about how to control the pandemic, preserve lives, avoid social disruption, and protect the economy. Not only this paper aims to further improve the health policies and guidelines for other regions to prevent and prepare for future pandemics, but it also summarizes the development trend of epidemics in Shanghai and Beijing from March to June 2022. Plus, the literature regarding prevention and control measures from Shanghai and Beijing are consulted and summarized as well. The data in this article was gathered from open reports, pertinent literature, and the local health committee's official website. Open reports typically refers to government reports, academic papers, and news articles which published online and can be accessed by anyone. Pertinent literature refers to relevant academic or scientific studies, publications, or research in the field. This include studies that have been conducted by experts in the subject matter, peer-reviewed articles, and books. Local health committee's official website refers to local government agencies or non-governmental organizations responsible for health-related matters. By gathering information from these multiple sources, a comprehensive and accurate account of the topic at hand can be provided to support claims.

2. Overview of the epidemics in Shanghai and Beijing

2.1. Development trend of the epidemic in Shanghai

From February 26, 2022, to June 30, 2022, a total of 649,662 local cases of infections were reported in Shanghai, including 58,137 confirmed cases, 591,525 asymptomatic infections, and 588 deaths.[1] Judging from the development trend of the current round of the COVID-19 epidemic in Shanghai, which is shown in Figure 1 and the data are available that the changes in the number of new confirmed cases and asymptomatic infections of the epidemic in Shanghai first remained at a low level, then increased rapidly, and then gradually decreased after a period of fluctuation. Since June 1st, Shanghai has maintained a single-digit or low level of new confirmed cases and new asymptomatic infections for one month in a row. The current round of the epidemic in Shanghai lasted for nearly 4 months.

Details on the prior Shanghai Municipal Health Commission News Center Daily News Release Statistics report can be found at: https://wsjkw.sh.gov.cn/xwfb/20220701/701ab5f0a08d4327ab4174d1ce.

2.2. Development trend of the epidemic in Beijing

From 00:00 on April 22, 2022, to 24:00 on June 30, 2022, Beijing had reported a total of 2,325 community cases of his COVID-19 epidemic, including 1788 confirmed cases of his and 537 asymptomatic cases, infected persons are indeed included. Among those infected, 69.38% had mild disease, 7.48% had a common disease, and 23.10% had an asymptomatic infection. There was only one severe patient and no critical illness or death.[2] Judging from the development trend of the current round of COVID-19 in Beijing, which can be shown in Figure 2, the COVID-19 pandemic is generally characterized by a fluctuating increase; throughout the analysis period, the number of new confirmed cases and new asymptomatic infections was in low increase, and the proportion of previously asymptomatic infections turned into confirmed cases was low (5.26%). Several peaks are related to several large-scale clustered epidemics in the corresponding time period.

2.3. Analysis of the spread characteristics of the epidemic

The COVID-19 epidemic in the current round in Shanghai and Beijing was sequenced by the two cities' CDC virus gene sequencing results, and it was shown that they were all Omicron variant strains (most of them in Shanghai were Omicron BA.2 and BA). 2.2, which has the characteristics of a short incubation period, rapid transmission, strong infectivity, strong concealment, and immune escape (5). Studies have shown that the R0 (basic reproduction number) of Omicron BA.1 is 9.5, the transmission ability of BA.2 is 1.4 times that of BA.1, and R0 is about 13.3 (6).

This round of epidemic in Shanghai is the most severe one since then. In the early stage of the epidemic, the source of infection was focused on the contamination of the environment by the virus carried by imported cases from other countries, which caused local infection (7), resulting in multi-chain parallel, multi-point community

1 Data source: Daily news release statistics of Shanghai Municipal Health Commission News Center. https://wsjkw.sh.gov.cn/xwfb/20220701/701ab5f0a08d4327ab4174d1ce.

2 Data source: Venezuelan news releases statistics daily. http://wjw.beijing.gov.cn/xwzx_20031/wnxw/index.html.

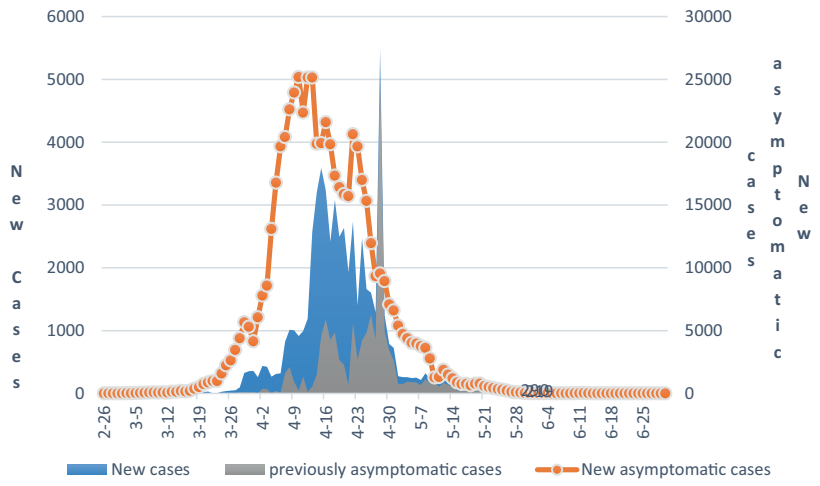

FIGURE 1
The development of the COVID-19 epidemic in Shanghai.

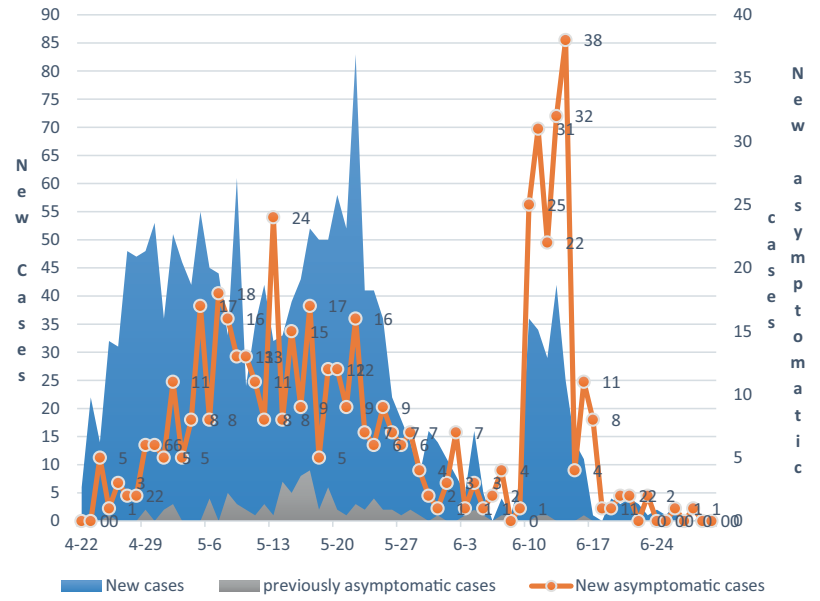

FIGURE 2
The development of the COVID-19 epidemic in Beijing.

transmission, the high incidence in local areas, and rapid spread. The following are the key symptoms: First, a substantial percentage of reported infections (91.1%) are asymptomatic infections, which are more latent and difficult to detect. Second, the current outbreak is extensive, affecting a variety of metropolitan populations from different racial and ethnic backgrounds, and the chain of transmission is intricate. Third, there are more people entering the country and more cases being imported, there are more investigative assistance missions being sent to national regions, and local epidemics are entwined and overlapped. a significant impact on the city's isolation. Housing options and medical care (8). The current round of the epidemic in Beijing presents the characteristics of rapid spread, multiple points and wide areas, and there are sporadic hidden sources of infection in society. The Beijing Center for Disease Control and Prevention analyzed the cases that caused more secondary infections since April 22 and found the following characteristics: First, there were lots of gatherings during the infectious period, which led to clustered epidemics; second, those who are unvaccinated are more likely to contract an illness; third, the range of activities is greater, which causes the epidemic to spread to various locations. Compared with the epidemic in Shanghai, the early infections in Beijing's current round of epidemics originated from the spillover of clustered epidemics outside Beijing, and the transmission chain is relatively clear (9); the number of asymptomatic infections is small (23.1%), and most of the infected cases (93.1%) were discovered during isolation control, and social screening cases accounted for only 6.9%.

3. Summary of public health epidemic control measures in Shanghai and Beijing

According to a "conceptual model of major epidemic crisis governance system and mechanism" based on theories of crisis management and collaborative governance, which was constructed by some scholars, this article summarizes the public health epidemic prevention and control strategies and measures from this round of epidemic in Shanghai and in Beijing. The difference in government management, social management, and professional management concerning COVID-19 policy and strategic areas was discussed in detail.

3.1. Epidemic control measures in Shanghai

3.1.1. Government governance perspective

Nowadays, the COVID-19 pandemic is still the biggest uncertainty affecting the world economy. On March 17, according to General Secretary Xi Jinping's speech at the meeting of the Standing Committee of the Political Bureau of the CPC Central Committee that striving to achieve the greatest effect of prevention and control at the lowest cost and minimize the impact of the epidemic on economic and social development, it shows the determination and confidence in coordinating epidemic control strategies and economic and social development (10). Non-pharmaceutical interventions such as lockdown management are effective in reducing the infection among close contacts and frontline healthcare workers to minimize the spread of the virus in the community and even contain the pandemic (11). How to balance epidemic prevention measures and economic development poses a huge challenge for decision-makers. As one of the megacities in China, Shanghai plays a significant role in national economic development and technological innovation (3). Some scholars use high-frequency truck flow data between cities to estimate the impact of the closure on the city's real income and the resulting spillover effects. The results of the study show the impact on the total real income of implementing a full-scale lockdown for one month in each city, with the three most affected cities being Shanghai, Beijing, and Shenzhen, where a full-scale lockdown would reduce total real income by 2.7% in each of these cities, 2.5 and 1.8% (11). Meanwhile, after the closure of Shanghai, factories in the city shut down, commerce was static, consumption decreased, and tax revenue suffered huge losses. In addition, core technologies of many industries such as chips, semiconductors, new energy vehicles, and artificial intelligence are in Shanghai. After the city closed, all upstream and downstream enterprises in the supply chain were affected. Considering the contradiction between epidemic prevention measures and economic development, coupled with the insufficient understanding of Omicron in the early stage (12), At the start of this outbreak, Shanghai did not take any precautions to shut down the city, which allowed the Omicron mutant strain to spread covertly. Rapid growth in the number of asymptomatic infections has created precise prevention and control challenges.

3.1.2. Social governance perspective

The large-scale infection of the Omicron strain has exposed many problems from the perspective of social governance. One is the issue of emergency supplies. The outbreak of the epidemic has had a sudden impact on the supply chain of many commodities, especially the emergency supplies that are closely related to the epidemic, which is often in short supply under the circumstances of growing demand and limited supply (13). Emergency material security is an important basis for coordinating economic development, ensuring people's livelihood, and preventing and defusing major risks (14). The attack of this round of Omicron mutant strains has exposed Shanghai's relatively lagging in terms of emergency material reserves such as limited storage capacity, single stock varieties, unreasonable division of blocks, and emergency logistics and poor transportation (14), resulting in chaotic situations such as difficulties in ensuring the supply of living materials for residents and driving up prices in the early stages of this round of epidemic. The second is the shortage of medical resources and the breakdown of manpower. Due to medical fragility and the destruction of the balance of medical resources under sudden outbreaks (15), designated hospitals, shelter hospitals, or centralized isolation sites were operating at full capacity during the high-level operation of this round of epidemic in Shanghai, and medical staff and medicines were insufficient; Large-scale test for COVID-19 has raised the demand on the number and capacity of personnel from the community, volunteers, medical institutions, and testing institutions (16). At the same time, the lack of professional facilities and capacity building in the infection wards of some general hospitals has brought challenges to the routine medical treatment and emergency service needs of critical patients with chronic diseases (17). The third is related to primary care. Primary care should be the backbone of any healthcare system. It is community-based (18). At present, the resident population of Shanghai has exceeded 20 million, but the scale of the community is still limited and the relationship between power and responsibility is not equal. As a result, the capacity of the community is insufficient which is unable to respond to the needs of large-scale epidemic control. It should also take a lot of time to link up the actions of various parties, such as medical groups, supply guarantee units, property management, and the government (19).

3.1.3. Professional governance perspective

Professional governance is the technical dimension of Shanghai's "balanced anti-epidemic" model. Before this round of epidemic, Shanghai's relatively successful anti-epidemic was based on professional measures against virus transmission (4). However, in the face of this round of sudden outbreaks, Shanghai did not fully follow medical knowledge and scientific strategies and did not take decisive measures in the early stages of the outbreak. As a result, the current round of epidemics had spread in Shanghai for more than a month before large-scale lockdown measures were implemented, resulting in widespread community dissemination. It can be seen that improving the ability of epidemic prevention and early detection, timely diagnosis and adopting movement restriction measures are effective public health interventions for the prevention and control of Omicron (5). In addition, the current outbreak of the Omicron epidemic has exposed the lack of effective emergency plans in society. Professionals had predicted that the epidemic would come in waves and would even have larger-scale outbreaks than the previous ones before the current round of outbreaks in Shanghai. However, in the early stages of the outbreak, Shanghai lacked a set of general social contingency plans to adhere to, and most of the temporary plans were poorly executed, squandering resources, and delaying possibilities for the response. For

instance, the government has prepared over 1,000 supply guarantee firms for material dispatch after people remain at home, but these temporary supply guarantee companies are unequal. Large enterprises that already have a complete set of logistics systems have not tried their best to mobilize them, and there is no contingency plan for the mobilization of social resources (13). At the same time, there are governance shortcomings such as insufficient anti-epidemic norms, unbalanced development, limited emergency response capabilities, and unsound coordination and cooperation mechanisms in community participation in epidemic prevention (20).

3.2. Epidemic control measures in Beijing

3.2.1. Government governance perspective

Based on the knowledge and preventative strategies learned from Shanghai's epidemic prevention and control, policymakers swiftly reach a consensus. The epidemic prevention and control authorities in Beijing have a thorough understanding of the prevention and control policies established by the CPC Central Committee based on the experience and control measures from Shanghai, unwaveringly adhere to the general policy of "dynamic clearing," and strictly and fervently follow it considering the strong infectiousness, rapid transmission, high proportion of asymptomatic infections, and strong occult transmission of the Omicron. From the beginning of the outbreak, Beijing's leaders adopted a hard political stance. Plus, different departments understood the relevant policies and clarified their respective tasks (21).

3.2.2. Social governance perspective

First, all citizens in Beijing participated in the whole process of epidemic prevention and control. The "four-party responsibility" system of territories, departments, units, and individuals should be fully implemented, the whole people should be mobilized and the whole city should be controlled, and it should be clarified that any unit, enterprise, and individual is responsible for assisting, cooperating, and obeying the prevention and control work organized by government departments under self-protection, otherwise they will be held accountable in accordance with the law (21).

For instance, the business license for the Paradise Supermarket bar outbreak on June 9 has been canceled, and the appropriate parties responsible have been permitted to be arrested. The second is to implement several safeguards to guarantee various daily demands. Several steps have been actively implemented to assure the market supply of daily requirements in the capital during the implementation of the epidemic prevention and control activities, including stable trading of refined grain and oil products and adequate reserves. According to the Beijing Municipal Bureau of Commerce, the supply of various daily necessities in Beijing is sufficient and stable, and the supply is guaranteed. Beijing attaches great importance to the construction of an emergency material support system. In addition to the government's storage of strategic materials, it also entrusts commercial enterprises to store a large number of daily necessities (22). The third is to strengthen community governance, forming a grid-based management team composed of government officials, volunteers, and other community workers. The mechanism of community consultative democracy has been continuously deepened, and a multi-dimensional co-governance community should be carried out, forming a grassroots governance structure involving the participation of neighborhood committees, owner committees, property management, volunteers, and residential units, etc. (18). A successful partnership between CDC and the community was established to assist people with functional needs. Community systems for medication and information distribution were fully used.

3.2.3. Professional governance perspective

Compared with Shanghai, the prevention and control authorities in Beijing made decisive decisions in the early stage of this round of the COVID-19 epidemic. The speed and efforts of the prevention and control in Beijing far exceeded those in the previous outbreaks of the original strain of COVID-19, Alpha, and Delta. Since the first new case in the COVID-19 outbreak on April 21, the epidemic prevention authorities found cases in Huairou, Pinggu, and other scenic spots through investigation. The epidemic prevention authorities quickly carried out testing around the scenic spots. On April 22, 15 new confirmed cases were reported in Pinggu District, Dongcheng District, Chaoyang District, Shunyi District, and other areas. The scope and risk of virus transmission increased. By April 23, it was found that there were confirmed cases involving the schools, and the prevention and control authorities were aware of the possibility of multiple outbreaks. At 5 PM on the 23rd, the affected portions of Panjiayuan Street have swiftly declared a closed area and a restricted area for strict monitoring to stop the epidemic's unchecked spread. The prevention and control authorities have put plans in place to halt the epidemic's spread as quickly as possible. There was widespread screening, testing, and prompt contact tracing. Early, forceful action promptly and successfully controlled the infection source and broke the chain of epidemic transmission.

4. Discussion

4.1. Heighten ideological understanding and adhere to the general policy of "dynamic clearing"

The continuous mutation of the COVID-19 strain has made precise prevention and control more difficult. Some studies have shown that although the fatality rate during the epidemic of the Omicron variant did decrease, the total number of deaths caused by the epidemic during the same period was higher than that of the Delta variant, and the harm of Omicron epidemic was still serious (23). China has a large population with a large elderly population, unbalanced regional development, and insufficient medical resources. The relaxation of prevention and control measures will inevitably lead to large-scale infection, severe illness, and death. Economic and social development and people's health will be seriously affected. We must have a deep, complete, and comprehensive understanding of the guidelines and policies for epidemic prevention and control.

4.2. Optimize prevention and control strategies, and strengthen precise prevention and control, and monitoring

Because of the characteristics of the Omicron mutant strain, on the one hand, it is necessary to strengthen the rapid, decisive, and

thorough adoption of relevant prevention and control measures, and at the same time continuously optimize and improve prevention and control strategies, strengthen precise scientific prevention and control, and strictly implement normalized epidemic prevention and control measures, implement the requirements of human, physical and environmental coordination (24). The review conducted by Ren demonstrate that Omicron is highly transmissible and faster spread, hence early prevention like vaccination should be taken into consideration, which is consistent with our findings (25). We should balance the relationship between epidemic prevention and control, social and economic development, and normal production and life to the greatest extent. Monitoring is an extremely effective tool for early detection. If the monitoring is done correctly, the sooner the patient is located, the sooner we can act. To minimize the spread of the outbreak, we'll make sure it's identified and addressed as soon as possible. We will enhance all aspects of the early warning and multi-channel monitoring systems, as well as the monitoring, early warning, and emergency response capabilities related to epidemics on the other side, it is essential to enhance the COVID-19 normalized testing mechanism, support regional screening, further improve the design of sampling locations, and satisfy public demand for formalized testing. It is necessary to do a good job in the monitoring and management of key populations, key places, and key institutions. Molecular tests such as PCR, as one of the major methods for the detection of SARS-CoV-2 infection, have proven to be crucial to the COVID-19 pandemic response. Antigen rapid detection tests detect viral proteins and, although they are less sensitive than molecular tests, have the advantages of being easier to do, giving a faster time to result, being lower cost, and being able to detect infection in those who are most likely to be at risk of transmitting the virus to others (26). It is necessary to make good use of the effective combination of antigen screening and testing and diagnosis as a monitoring method to detect infected people as early as possible and prevent them from happening. It is also necessary to prevent missed detection caused by irregular sampling due to problems such as insufficient manpower, overloaded work, inadequate protective measures, and insufficient protective awareness, failing to detect potential cases in time (27). All these measures continue to have a crucial role in the transition from pandemic response to pandemic control.

4.3. Strengthen community prevention and control, and control the spread of the epidemic as soon as possible

There are two basic fronts in COVID-19 epidemic prevention and control, one is patient treatment, and the other is community prevention and control (28). Communities are densely populated, complex, and have a large flow of people. They play a significant role in joint prevention and control of the epidemic, and can effectively defense by preventing the import from outside and the spread from inside (27). Effectively implement the responsibilities of the four parties, give full play to the roles of neighborhood committees, villagers' committees, public health committees, and volunteer organizations, organize government officials to effectively sink into the community, implement divisional contracting, and make good use of township health centers, community service centers, and village clinics in the community. In the handling of the epidemic, it is necessary to be more efficient and coordinated, to ensure the mutual coordination of testing, epidemiological investigation, quarantine and treatment, and community control. Various systems and various types of information should be interconnected to ensure that the community is informed in time. Peronace also claimed in her research that prompt information sharing among global public health partners should be significant in pandemic prevention and control (28). We should take more practical and thoughtful measures to ensure the work and livelihood of front-line staff, and allocate human resources appropriately. A successful partnership between CDC and the community should be established to assist people with functional needs. Community systems for medication and information distribution can be fully used (29).

4.4. Make emergency plans and preparations, strengthen training mechanism

To achieve good results in epidemic prevention and control, in addition to the patient treatment and community prevention and control, the full participation of the whole people and society is still needed. In the wake of the lockdown, many cities have experienced inadequate public services, such as weak epidemic prevention and control, chaotic social order, and lack of material support. Facing the emergency, the entire society lacks effective emergency plans. After SARS, China established a "one case, three systems" emergency management system with Chinese characteristics. The emergency plan of the pertinent medical and health departments has also been revised and improved considering the COVID-19 epidemic test, but other pertinent departments of epidemic prevention and control, such as production, living, education, recreation, transportation, and public services, should also make the necessary emergency preparations. Different epidemic scenarios should be addressed by emergency plans, and essential employees should also undergo more training and drills. Consolidate primary responsibilities, strengthen the normalized prevention, and control of key locations, and implement comprehensive prevention and control strategies and emergency plans. Adhere to the problem-oriented approach to strengthen prevention and control preparations, strengthen regional defense assistance, and provincial overall planning, and take multiple measures simultaneously. Strengthen shelter hospitals, designated hospitals, centralized isolation points, and related prevention and control materials. During the epidemic prevention and control period, we must also make preparations and related plans for how to ensure the normal life of people in the community (30–34). Since the coronavirus pandemic represents a worldwide health emergency, coordinated actions are required to address it. The epidemic prevention and control strategies used in Beijing and Shanghai serve as a model for other places, helping us to better prepare for COVID-19 and other potential risks to public health in the future. As previously said, it is advised to follow the general strategy of "dynamic clearance," put precise prevention and monitoring in place, improve community control, and develop emergency plans and preparations. All these

measures continue to have a crucial role in the transition from pandemic response to pandemic control.

5. Conclusion

From the above discussion, the conclusion can be reached that by serving and providing a guide for other regional places, this study set out to advance and guide the epidemic prevention and control methods, and practices and strengthen people's ability to respond to COVID-19 and other future potential public health risks. A comparative analysis was conducted that the COVID-19 epidemic development trend and prevention and control effects both in Beijing and Shanghai has extended our knowledge of the differences between governmental, social, and professional management were discussed and explored, regarding the COVID-19 policy and strategic areas. The insights gained from this study may be of assistance to prevent and be ready for potential pandemics. This study has found that generally that Shanghai, which had achieved relatively good performance in the fight against the epidemic, has exposed limitations in its epidemic prevention and control system in the face of Omicron. In fact, the city of Beijing has undertaken prompt and severe lockdown measures and achieved rather good results in epidemic prevention and control because of learning from Shanghai's experience and lessons; adhering to the overall concept of "dynamic clearing," implementing precise prevention and monitoring, enhancing community control, and making emergency plans and preparations. All these actions and measures are still essential in the shift from pandemic response to pandemic control. Different places have introduced different urgent policies to control the spread of the pandemic. Strategies to control COVID-19 have often been based on preliminary and limited data and have tended to be slow to evolve as new evidence emerges. Hence, the effects of these anti-epidemic policies need to be further tested. This would be a fruitful area for further work.

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.

Author contributions

YLM analyzed and interpreted the data, designed the study, and performed the research. XW was a major contributor in writing the manuscript. AYM and WQQ developed the idea for the study and provided supervision. PD, YJY, and GYH conceived the idea and helped collect the data. KW and XLY contributed to the revisions. All authors listed have made a substantial, direct, and intellectual contribution to the work. They have read and approved the final manuscript for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Geographic heterogeneity of the epidemiological impact of the COVID-19 pandemic in Italy using a socioeconomic proxy-based classification of the national territory

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Objectives: This study aimed to evaluate the differences in incidence, non-intensive care unit (non-ICU) and intensive care unit (ICU) hospital admissions, and COVID-19-related mortality between the "inner areas" of Italy and its metropolitan areas.

Study design: Retrospective population-based study conducted from the beginning of the pandemic in Italy (20 February 2020) to 31 March 2022.

Methods: The municipalities of Italy were classified into metropolitan areas, peri-urban/intermediate areas and "inner areas" (peripheral/ultra-peripheral). The exposure variable was residence in an "inner area" of Italy. Incidence of diagnosis of SARS-CoV-2 infection, non-ICU and ICU hospital admissions and death within 30days from diagnosis were the outcomes of the study. COVID-19 vaccination access was also evaluated. Crude and age-standardized rates were calculated for all the study outcomes. The association between the type of area of residence and each outcome under study was evaluated by calculating the ratios between the standardized rates. All the analyses were stratified by period of observation (original Wuhan strain, Alpha variant, Delta variant, Omicron variant).

Results: Incidence and non-ICUs admissions rates were lower in "inner areas." ICU admission and mortality rates were much lower in "inner areas" in the early phases of the pandemic, but this protection progressively diminished, with a slight excess risk observed in the "inner areas" during the Omicron period. The greater vaccination coverage in metropolitan areas may explain this trend.

Conclusion: Prioritizing healthcare planning through the strengthening of the primary prevention policies in the peripheral areas of Italy is fundamental to guarantee health equity policies.

KEYWORDS

COVID-19, geographic inequalities, rural, metropolitan, social vulnerabilities

Introduction

Italy has been one of the countries hit hardest by the COVID-19 pandemic. Official estimates report that at the beginning of October 2022, about 41% of the resident population of Italy had contracted the virus (1). This proportion is obviously underestimated, especially since the spread of the Omicron variant, both because only some of the asymptomatic cases have been diagnosed, given that contact tracing has been essentially suspended, and because of the widespread use of COVID-19 home testing kits. By the same date in early October, COVID-19 had caused 177,000 deaths in Italy, with one of the highest mortality rates in the world before the introduction of the vaccine, and with mortality remaining high despite extensive vaccination coverage (1). COVID-19 has contributed to widening socioeconomic inequalities both directly and indirectly. Directly, the most disadvantaged social groups of the population (2, 3), including immigrants (4), have been more seriously affected, in terms of the number of infections and outcomes. With the obvious exception of healthcare professionals, these same disadvantaged individuals have been indirectly impacted by the suspension and rescheduling of all non-urgent care so as to provide medical assistance to COVID-19 patients. During the pandemic, a reduction in access to healthcare services has been observed, in part due to the saturation of availability of services because of the COVID-19 emergency but also due to the perception, real or otherwise, that healthcare facilities are potential sources of infection. The reduction in access has been higher among the most socioeconomically disadvantaged groups of the population (5).

Even before the pandemic, individual socioeconomic inequalities in Italy were compounded by geographic area-related inequalities. Regardless of socioeconomic level, in fact, the life expectancy of individuals residing in the southern regions of Italy is 1 year less than that of persons residing in the central and northern regions (6). This is true for education level as well, which is known to be a robust proxy for individual socioeconomic level (6). The differences in life expectancy between the North and the South, which decreased in 2020 as an effect of the pandemic (the first wave struck especially the northern regions), increased in 2021, reaching a value of 1.7 years (7).

A considerable amount of literature has been published on the evaluation of the role of living environment in health behaviors and outcomes, analyzing the geographic heterogeneity in regional areas that do not necessarily correspond to regional, provincial, or municipal administrative areas. This literature has focused in particular on the concepts of urbanization and of population density (8).

Living in an urban context is associated with a higher incidence of environmental pollution-related diseases (9), while in rural areas higher incidences of and mortality due to diabetes (8, 10, 11), screening-preventable (12, 13) or lifestyle-associated (13) cancer, and suicide (14) have been observed. Regarding cardiovascular diseases, the evidence has not always been consistent (8, 15). The differing distribution of distal social determinants such as poverty, low socioeconomic level (16), and/or belonging to an ethnic minority (17), associated with an unhealthy lifestyle, are often at the root of the geographic differences observed.

The COVID-19 pandemic has had a very heterogenous impact on populations. Known risk factors like population density of the area of residence, dwelling density, and mobility (18) have interacted with conditions of health and social vulnerability, determining worse outcomes in disadvantaged groups. The term syndemic has often been used to describe a health outcome determined by indissolubly intersecting diseases and social factors (19, 20).

In this sense, although an urban setting is a potential risk factor for infection, it has been seen that the pandemic has struck rural areas in a number of countries (21–24) more harshly in terms of the number of infections and of mortality, except in the first wave.

Nevertheless, studies on geographic differences in the epidemiological impact of the pandemic have been mainly conducted in the United States, especially, and some developing countries (19, 20, 25–29), despite the topic being extremely relevant to public health decision-making worldwide, including Italy (30). In Italy, the National Strategy of "Inner Areas" (SNAI) recently created a new classification of municipalities, with six categories on the basis of the distance to the nearest metropolitan area: metropolitan (municipal or intermunicipal), peri-urban, intermediate, peripheral, ultra-peripheral. The "inner areas" include peripheral and ultra-peripheral municipalities and are characterized by the paucity of essential services such as education, mobility, and healthcare. These areas thus have a high risk of social deprivation and health and social care vulnerability, factors that are closely correlated with COVID-19.

Objective

The aim of the study was to evaluate the differences in incidence, non-intensive care units (non-ICU) and intensive care unit (ICU) admissions, and mortality between the "inner areas" and the metropolitan areas of Italy.

Methods

Study design

The study was based on the resident population in Italy on 1 January 2020. The database used to quantify the cases and outcomes of COVID-19 was the COVID-19 Integrated Surveillance System of the Italian National Institute of Health (24). In accordance with Italian law N. 52 of 19 May 2022, following the law decree N. 24 of 24 March 2022 (Article n. 13), the information on vaccination coverage was retrieved by the Italian National Institute of Health using data from the National Immunisation Information System of the Italian Ministry of Health.

Exposure

The exposure variable for the study was residence in an "inner area" of Italy, as defined based on the municipality.

To classify the municipalities of Italy, we adopted the concept of "inner areas" according to the meaning and the methodology defined in the 2014–2020 SNAI planning cycle, updated for the 2021–2027 planning cycle. The SNAI is a strategic plan of the Italian Territorial

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Cohesion Agency,[1] a public body supervised by the President of the Council of Ministers whose objective is to promote economic development and territorial cohesion so as to eliminate the territorial differences throughout the country and to strengthen the administrative abilities of the administrations.

The general objective is to support and develop rural areas that are in decline or at demographic risk but whose active community supervision is crucial to the overall maintenance of the territory in terms of hydrogeological profile, landscape, and cultural identity (31). "Inner areas" are often characterized by considerable environmental (water resources, agricultural systems, forests, natural and human landscapes) and cultural (archaeological sites, historical settlements, abbeys, small museums, craft centers) resources. They therefore have great tourism potential, but they are far from the main cities that provide essential services such as education, health, and mobility, all of which are available in metropolitan areas.

The classification adopted defines a metropolitan area (municipal or intermunicipal) as contiguous municipalities or groups of municipalities that can jointly provide the following essential public services: at least one classical or scientific high school (*liceo*) and one vocational school or technical institute, an Urgent Care center, and a train station.

The municipalities that are not part of a metropolitan area (municipal or intermunicipal) are classified in one of four categories (peri-urban, intermediate, peripheral, ultra-peripheral) according to the distance in terms of average driving time to the nearest metropolitan area. "Inner areas" include peripheral and ultra-peripheral categories. The distance is categorized according to the mean, the third quartile, and the 95th percentile of overall distribution. Specifically, the classification of Internal Areas updated for the 2021–2027 planning cycle was used, which refers to all the Italian municipalities in 2020 ($n = 7{,}903$). The municipalities with a driving time distance from a municipal (A) or intermunicipal (B) metropolitan area closest to the distribution mean value (27.7 min) were classified as peri-urban (C – 3,828 municipalities); over that value and up to the value of the third quartile (40.9 min), they were classified as intermediate (D – 1,928 municipalities). Over that value and up to the 95th percentile (66.9 min), they were classified as peripheral (E – 1,524 municipalities). Finally, those over the 95th percentile (more than 66.9 min) were classified as ultra-peripheral (F – 382 municipalities). For the purpose of the study, the six categories were aggregated into three classes: metropolitan areas (A + B), peri-urban/intermediate areas (C + D), and "inner areas" (peripheral/ultra-peripheral) (E + F). Figure 1 illustrates the distribution of the municipalities according to the adopted classification.

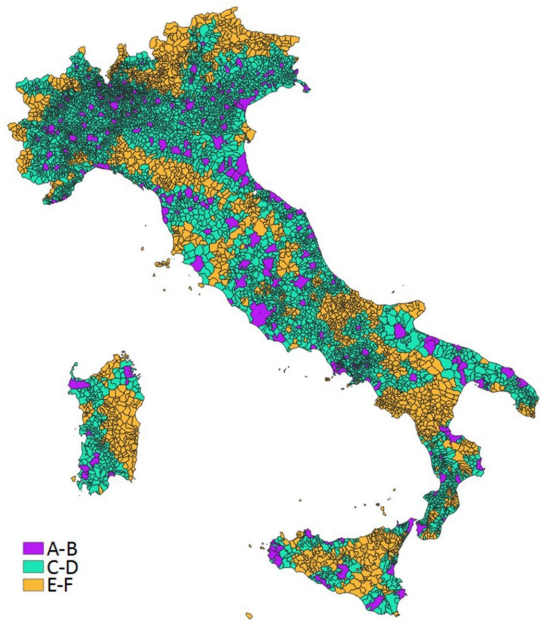

FIGURE 1
Distribution of the municipalities in metropolitan (A-B), peri-urban/intermediate (C-D) and inner (E-F) areas.

Study period

The period of time considered in this study was from the beginning of the pandemic in Italy (20 February 2020) to 31 March 2022.

The analyses were stratified in periods based on the predominance of the different variants during the course of the pandemic (32). Specifically, four time periods were defined as follows:

1. 20 February–31 December 2020, characterized primarily by the original Wuhan strain
2. 1 January–30 June 2021, characterized primarily by the Alpha variant
3. 1 July–31 December 2021, characterized primarily by the Delta variant
4. 1 January–31 March 2022, characterized primarily by the Omicron variant

Outcomes

The following outcomes were analyzed:

– Incidence of diagnosis of SARS-CoV-2 infection confirmed by PCR or, from 15 January 2021, by antigen test;
– Incidence of non-ICU hospital admissions, ICU hospital admissions, and death within 30 days from diagnosis.

COVID-19 vaccination access was also evaluated.

Statistical analyses

The demographic and territorial characteristics of the resident population of each of the three classes of municipalities (metropolitan areas, peri-urban/intermediate areas, inner areas) are described

1 https://www.agenziacoesione.gov.it/

according to the following variables: population density (people per km^2), surface area, percentage of population in the municipalities with <10,000 inhabitants and more than 50,000 inhabitants, sex, age class (0–14, 15–29, 30–44, 45–59, 60–74, and >74 years), geographic area of residence (North-West, North-East, Center, and South and Islands), *per capita* taxable income (measured in Euro) and social and material vulnerability index. Information about the level of social and material vulnerability of the municipality of residence was retrieved from the 8milaCensus platform managed by Istat (33). This multidimensional indicator, updated to 2011, has been computed by ISTAT at the municipality level, on the basis of seven socio-economic indicators measuring the incidence of: population with age between 25 and 64 that is illiterate or without qualification; families with at least six members; single parent families (with age of parent up to 64) over the total of families; families with possible welfare poverty; population living in severely crowded conditions; young people (15–29 years) without occupation; families with children with potential economic poverty.

The distributions of COVID-19 cases, non-ICU and ICU hospital admissions, and deaths were also analyzed.

Crude and standardized rates by age, with 95% confidence intervals (CI), were calculated for all the study outcomes. Standardization by age was performed with the direct standardization method, taking as the standard population of reference that of the total resident population on 1 January 2020. The association between the type of area of residence and each outcome under study was evaluated by calculating the ratios between the standardized rates (RR) with 95% CI, considering the AB municipality class as the reference category. All the analyses were stratified by period of observation. The analysis further stratified by geographic area of residence is provided in the Supplementary material.

A supplementary analysis was performed on COVID-19 vaccination access. For the population of individuals at least 5 years of age, those who had received at least one dose of the vaccine during the period under study were considered vaccinated, and the crude and standardized rates of vaccination were calculated by age (with relative 95% CI), stratified by type of municipal area and of geographic area of residence. Any difference between areas in terms of vaccination access were evaluate using the calculation of the RR with 95% CI.

The analyses were performed using the SAS 9.3 software.

Results

According to the criteria of the classification adopted in this study, the "inner areas" of Italy cover 33.7% of the total national surface area and have 9.1% of the population, which in 2020 was 59,641,488 inhabitants. Of this total number of residents in the "inner areas," 63.4% live in the South and Islands, mainly in municipalities with a population of fewer than 10,000 inhabitants (63.6%) or with a very low population density of 53.6 people per km^2, against the 789 people per km^2 in metropolitan areas. In all the geographic areas the average pro capita taxable income was higher in the metropolitan areas, decreasing in the peri-urban/intermediate and again in the inner areas, which had the lowest values. A north–south gradient was also observed for all types of areas. Concerning the proportion of the population living in a condition of potentially serious social and material vulnerability, the lowest values were observed in the North of Italy (2.4% and 4.2%, in the inner areas of the North-West and the North-East, respectively). Significantly higher proportions were found in the Center (26.5% in the inner areas) and especially in the South and Islands (84.4% in the metropolitan areas; Table 1).

Table 2 reports the distribution of COVID-19 cases, non-ICU and ICU hospital admissions, deaths, and the crude and standardized rates of the outcomes under study, stratified by period, and class of municipalities. During the study period, a total amount of 14,364,240 cases of COVID-19, 459,249 non-ICU and 63,582 ICU hospital admissions, and 132,874 deaths were observed. In the inner areas, 7.8% of the total number of SARS-CoV-2 infections were registered, 7% of non-ICU admissions, 6.6% of ICU admissions, and 7.4% of deaths.

In the first two periods (Wuhan and Alpha), lower rates for all of the outcomes under study were observed in the inner areas compared to those in the metropolitan areas and in the peri-urban/intermediate areas. The incidence and non-ICU admission rates observed in the inner areas remained lower than those in the other areas in the subsequent periods (Delta and Omicron) as well, while no difference between areas was observed for the more serious outcomes (ICU admission and death).

The analysis of the rates stratified by geographic area of residence showed strong geographic heterogeneity (Supplementary Table 1): while the trend of the rates for the Center and for the South and Islands was in line with those at the national level, in the North it was not. Especially in the second period in both the North-East and North-West, the incidence of COVID-19 and non-ICU admissions were higher in the inner areas than in the metropolitan and peri-urban/intermediate areas. Furthermore, rates of ICU admissions (in the North-East in the first and second period) and of mortality (in the first period) were higher in the inner areas than in the metropolitan areas.

Figures 2–5 report the age-adjusted RR with relative 95% CI, stratified by period and class of municipalities for incidence, non-ICU admission, ICU admission, and death.

Regarding the incidence of COVID-19, rates in the inner areas in all phases of the pandemic were lower than those in the metropolitan areas, particularly in the periods of the original strain (RR: 0.672; 95% CI: 0.667–0.675), while slighter differences were seen during the Omicron variant phase (RR: 0.927; 95% CI: 0.925–0.930).

Non-ICU admission rates were always lower in the inner areas than in the metropolitan areas, especially during the Wuhan + Alpha phase (RR: 0.635; 95% CI: 0.623–0.648) compared to the Omicron phase (RR: 0.795; 95% CI: 0.773–0.816).

ICU admission rates were markedly lower in the inner areas during the Wuhan (RR: 0.547; 95% CI: 0.519–0.576) and Alpha (RR: 0.663; 95% CI: 0.628–0.701) phases. No significant differences were seen during the Delta phase, while a slight excess risk in the inner areas was observed in the Omicron phase (RR: 1.106; 95% CI: 1.004–1.219).

Mortality rates for COVID-19 were considerably lower in the inner areas during the first phase (Wuhan) of the pandemic (RR: 0.673; 95% CI: 0.652–0.695). However, this protection progressively diminished during the Alpha and Delta phases, and a slight excess risk was observed in the Omicron phase, at the limit of statistical significance (RR: 1.042; 95% CI: 0.987–1.100).

TABLE 1 Demographic and territorial characteristics of the resident population of metropolitan areas, peri-urban/intermediate and inner areas.

	Type of area						Total
	Metropolitan		Peri-urban/intermediate		Inner		
Population density (people per km^2)	789		185.6		53.6		197.4
Surface area (%)	9.3		57		33.7		100
% population resident in municipalities > 50,000 inhabitants	84.1		5.6		1.3		34.5
% population resident in municipalities < 10,000 inhabitants	0.3		45.8		63.6		30.5
Population	**N**	**Row %**	**N**	**Row %**	**N**	**Row %**	**N**
Total	22,235,272	37.3	31,959,035	53.6	5,447,181	9.1	59,641,488
Sex	**N**	**Col %**	**N**	**Col %**	**N**	**Col %**	**N**
M	10,656,285	47.9	15,714,537	49.2	2,679,274	49.2	29,050,096
F	11,578,987	52.1	16,244,498	50.8	2,767,907	50.8	30,591,392
Age class	**N**	**Col %**	**N**	**Col %**	**N**	**Col %**	**N**
0–14	2,797,537	12.6	4,272,663	13.4	657,354	12.1	7,727,554
15–29	3,276,155	14.7	4,843,140	15.2	836,143	15.4	8,955,438
30–44	4,102,231	18.4	5,966,309	18.7	973,556	17.9	11,042,096
45–59	5,273,366	23.7	7,627,866	23.9	1,262,728	23.2	14,163,960
60–74	3,979,202	17.9	5,680,507	17.8	1,029,015	18.9	10,688,724
75+	2,806,781	12.6	3,568,550	11.2	688,385	12.6	7,063,716
Geographic area[a]	**N**	**Col %**	**N**	**Col %**	**N**	**Col %**	**N**
North-West	4,275,406	19.2	6,628,128	20.7	724,003	13.3	11,627,537
North-East	5,903,317	26.5	9,612,967	30.1	472,395	8.7	15,988,679
Center	5,862,355	26.4	5,171,097	16.2	797,640	14.6	11,831,092
South and Islands	6,194,194	27.9	10,546,843	33	3,453,143	63.4	20,194,180
Population living in a condition of potential serious social and material vulnerability[b]	**N**	**Col %**	**N**	**Col %**	**N**	**Col %**	**N**
North-West	14,6,959	2.5	155,047	1.6	11,451	2.4	313,457
North-East	28,290	0.7	60,765	0.9	30,525	4.2	119,580
Center	269,857	4.6	1,034,799	20.0	211,175	26.5	1,515,831
South and Islands	5,225,123	84.4	7,074,534	67.1	2,368,782	68.6	14,668,439
Pro capita taxable income (Euro)[a,c]							
North-West	24,915		21,057		18,046		22,392
North-East	22,767		20,330		19,305		21,152
Center	22,673		18,279		17,605		20,405
South and Islands	18,690		15,052		14,021		15,952

[a]North-West (Piedmont, Val d'Aosta, Lombardy, Liguria); North-East (Veneto, Trentino Alto Adige, Friuli Venezia Giulia, Emilia Romagna); Center (Tuscany, Umbria, Marche, Lazio); South (Abruzzo, Molise, Campania, Apulia, Basilicata, Calabria) and Islands (Sicily, Sardinia).
[b]First quartile of the distribution of the social and material vulnerability index.
[c]Source: http://dati.istat.it.

The analysis of the data from the National Immunisation Information System showed national-level crude and standardized rates of COVID-19 vaccination access that were lower in the inner areas than in metropolitan areas (77.1 and 85.8%, respectively). The same was seen in all geographic areas, with more marked differences in the South and Islands, where vaccination access was even considerably lower (for all types of areas) than in the other geographic areas (Supplementary Table 2).

Discussion

This study aimed to evaluate the epidemiological impact of the COVID-19 pandemic on the inner areas of Italy. These areas include rural areas, those that have low or medium population density, and small villages and towns, in line with the methodology used for the classification. These areas are at high risk of social deprivation as they are considerably far from services of education, healthcare, and rail

TABLE 2 Distribution of COVID-19 cases, non-ICU and ICU hospital admissions, and deaths. Crude and age-standardized rates, with 95% confidence intervals (CI) for all the study outcomes, by class of municipalities and time period.

	Total	%	Wuhan				Alpha				Delta				Omicron			
			N	Crude rate *1000	Std rate *1000	95%CI	*N*	Crude rate *1000	Std rate *1000	95%CI	*N*	Crude rate *1000	Std rate *1000	95%CI	*N*	Crude rate *1000	Std rate *1000	95%CI
Incidence	14,364,240	100	2,115,782	35.48	35.48	(35.43–35.52)	2,050,899	34.39	34.39	(34.34–34.43)	2,118,525	35.52	35.52	(35.47–35.57)	8,079,034	135.46	135.46	(135.37–135.55)
Metropolitan areas	5,398,467	37.6	814,140	36.61	36.52	(36.44–36.60)	748,313	33.65	33.73	(33.66–33.81)	811,636	36.50	36.78	(36.70–36.86)	3,024,378	136.02	137.00	(136.85–137.16)
Peri-urban/ intermediate areas	7,842,018	54.6	1,167,550	36.53	36.66	(36.60–36.73)	1,144,136	35.80	35.73	(35.66–35.79)	1,156,556	36.19	35.94	(35.88–36.01)	4,373,776	136.86	135.84	(135.71–135.96)
Inner areas	1,123,755	7.8	134,092	24.62	24.52	(24.39–24.65)	158,450	29.09	29.24	(29.09–29.38)	150,333	27.60	27.90	(27.76–28.04)	680,880	125.00	127.01	(126.71–127.32)
Non-ICUs hospitalization	459,249	100	188,913	3.17	3.17	(3.15–3.18)	135,146	2.27	2.27	(2.25–2.28)	56,513	0.95	0.95	(0.94–0.96)	78,677	1.32	1.32	(1.31–1.33)
Metropolitan areas	184,037	40.1	75,422	3.39	3.30	(3.28–3.33)	53,454	2.40	2.35	(2.33–2.37)	23,061	1.04	1.02	(1.00–1.03)	32,100	1.44	1.40	(1.38–1.41)
Peri-urban/ intermediate areas	243,051	52.9	101,555	3.18	3.27	(3.25–3.29)	72,002	2.25	2.31	(2.29–2.33)	29,258	0.92	0.94	(0.92–0.95)	40,236	1.26	1.30	(1.29–1.31)
Inner areas	32,161	7.0	11,936	2.19	2.10	(2.06–2.14)	9,690	1.78	1.72	(1.68–1.75)	4,194	0.77	0.75	(0.72–0.77)	6,341	1.16	1.11	(1.08–1.14)
ICU hospitalization	63,582	100	29,446	0.49	0.49	(0.48–0.50)	22,689	0.38	0.38	(0.38–0.39)	6,471	0.11	0.11	(0.10–0.11)	4,976	0.08	0.08	(0.08–0.09)
Metropolitan areas	25,327	39.8	12,093	0.54	0.53	(0.52–0.54)	8,863	0.40	0.39	(0.38–0.40)	2,483	0.11	0.11	(0.11–0.11)	1,888	0.08	0.08	(0.08–0.09)
Peri-urban/ intermediate areas	34,055	53.6	15,708	0.49	0.50	(0.49–0.51)	12,362	0.39	0.39	(0.39–0.40)	3,419	0.11	0.11	(0.10–0.11)	2,566	0.08	0.08	(0.08–0.09)
Inner areas	4,200	6.6	1,645	0.30	0.29	(0.28–0.31)	1,464	0.27	0.26	(0.25–0.27)	569	0.10	0.10	(0.09–0.11)	522	0.10	0.09	(0.08–0.10)
Mortality	132,874	100	70,885	1.19	1.19	(1.18–1.20)	34,928	0.59	0.59	(0.58–0.59)	10,577	0.18	0.18	(0.17–0.18)	16,484	0.28	0.28	(0.27–0.28)
Metropolitan areas	51,589	38.8	27,178	1.22	1.16	(1.14–1.17)	13,807	0.62	0.59	(0.58–0.60)	4,261	0.19	0.18	(0.18–0.19)	6,343	0.29	0.27	(0.26–0.28)
Peri-urban/ intermediate areas	71,455	53.8	39,135	1.22	1.29	(1.28–1.31)	18,487	0.58	0.61	(0.60–0.62)	5,343	0.17	0.18	(0.17–0.18)	8,490	0.27	0.28	(0.28–0.29)
Inner areas	9,830	7.4	4,572	0.84	0.78	(0.76–0.80)	2,634	0.48	0.45	(0.43–0.47)	973	0.18	0.17	(0.16–0.18)	1,651	0.30	0.28	(0.27–0.29)

Crude and age-standardized rates, with 95% confidence intervals (CI) for all the study outcomes, by class of municipalities and time period.

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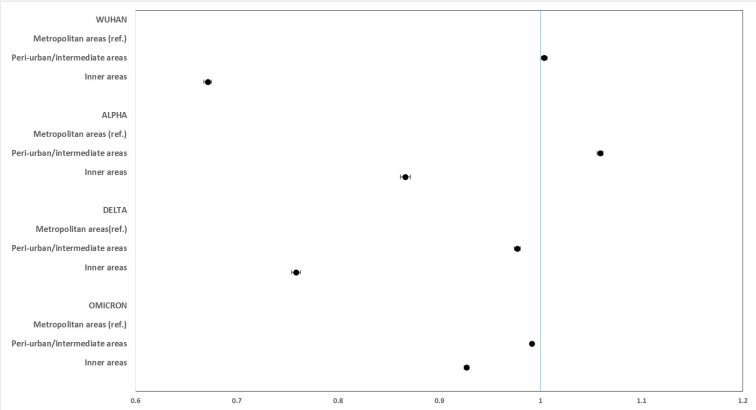

FIGURE 2
Age-adjusted rate ratios with 95%CI of COVID-19 incidence, by study period and class of municipalities. Metropolitan areas as reference category.

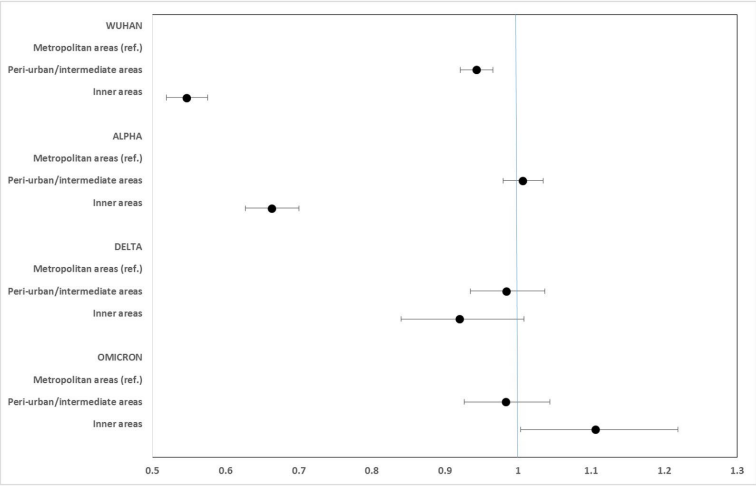

FIGURE 4
Age-adjusted rate ratios with 95%CI of ICU hospitalization, by study period and class of municipalities. Metropolitan areas as reference category.

transport, as well has having lower income levels. The results of the study show that the incidence of SARS-CoV-2 infection and non-ICU admissions were lower in the inner areas of the country than in the metropolitan areas in all of the time periods examined. These results are in line with those of another Italian study, which, however, used a different classification of the territory (34). The inner areas have a much lower population density than do the metropolitan areas as well as less mobility; both are important risk factors for the spread of infection, which could at least partially explain why there has been a lower incidence of COVID-19 in these areas. In the United States, instead, where most of the evidence on the geographic differences in the impact of the pandemic comes from, higher incidence rates were seen in rural areas (21, 35), leading to the hypothesis that the differences may depend mainly on a lower perception of risk and on a lower adherence to infection prevention measures there than in urban areas (21, 36).

We observed lower infection and non-ICU admission rates in rural areas in all of the time periods examined. ICU admission and mortality rates were also lower in the inner areas than in metropolitan areas, but only during the periods of the Wuhan strain and the Alpha variant. No differences were observed in the Delta variant period, and there was a higher risk of ICU admission and mortality in the inner areas during the Omicron variant phase.

Furthermore, additional analyses stratified by geographic area (Supplementary Table 1) showed that the national trend was the result of two opposing phenomena: while in the North the highest rates were in the intermediate areas, and in the Omicron phase, also in the inner areas, in the Center and the South rates were decidedly much higher in the metropolitan areas. Thus, one could speculate that living in the inner areas was protective against infection and non-ICU care admission, but that once infected, the probability of worse outcomes was greater, particularly in the most recent periods of the pandemic. While a number of factors may have contributed to determining this scenario, the heterogeneity in vaccination access throughout the country may

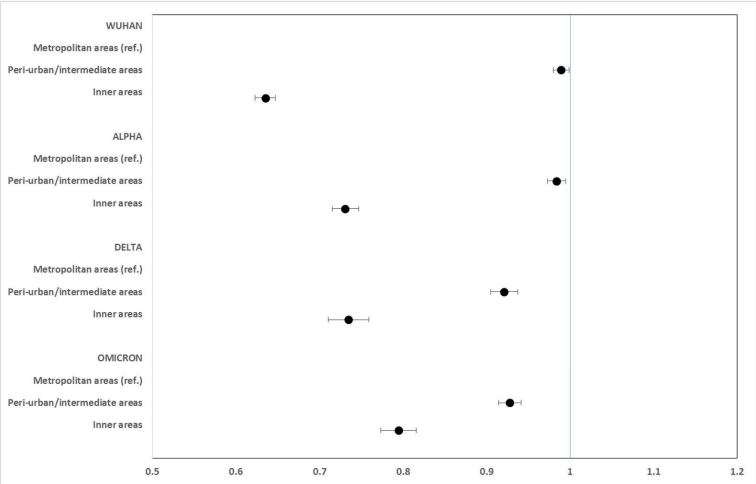

FIGURE 3
Age-adjusted rate ratios with 95%CI of non-ICU hospitalization, by study period and class of municipalities. Metropolitan areas as reference category.

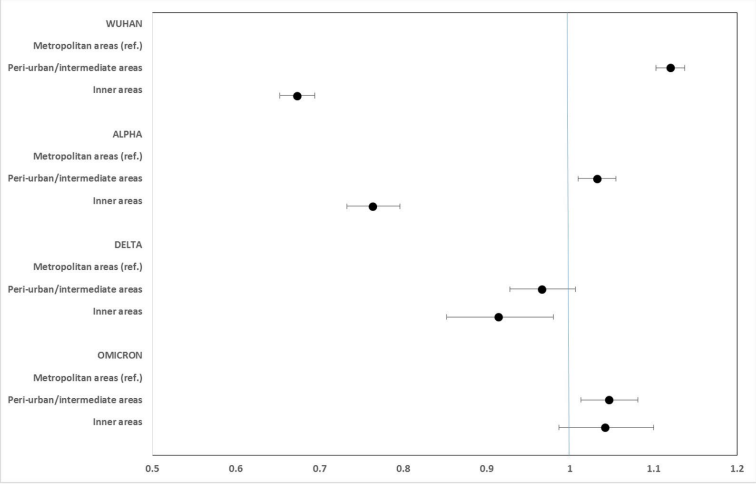

FIGURE 5
Age-adjusted rate ratios with 95%CI of mortality, by study period and class of municipalities. Metropolitan areas as reference category.

at least partially explain the phenomenon. As a matter of fact, the analyses performed on the data from the COVID-19 National Vaccination Registry (Supplementary Table 2) show that vaccine coverage with at least two doses was lower in the inner areas than in metropolitan areas in all geographic areas, particularly in the North-West and in the South. Other studies that compared COVID-19 vaccine coverage in urban and rural areas have shown lower vaccination access in rural areas (37, 38). The progressive inversion of the trend seen in the last two observation periods, especially in terms of the most serious clinical outcomes (ICU admission and death), may partially reflect the greater vaccine coverage achieved in metropolitan areas than in the inner areas starting from the second half of 2021, when the vaccination campaign had at that point been extended to almost the entire general population.

Although it is not possible to determine any geographic heterogeneity in terms of the comorbidities of COVID-19 patients, one could hypothesize that there is a greater proportion of subjects vulnerable to the outcomes of COVID-19 in the inner areas; previous analyses have shown higher mortality in inner areas for all causes and for stroke as well as for ischemic heart disease among males (39). Evidence from the U.S. shows a strong interaction between the geographic heterogeneity of the impact of COVID-19 and factors related to social vulnerabilities, such as occupation (25, 40). An Italian study has shown a higher prevalence of overweight and obesity in the rural areas and mountains of Veneto, a large region in the northeast of Italy (41). However, in our study, the worsening of outcomes in the inner areas was seen only in the most recent phases of the pandemic, which seems therefore to limit this possibility. It is plausible, in fact, that factors tied to the syndemic interpretation of the impact of the

pandemic and to access to healthcare, such as distance and/or scarcity of healthcare services, would have been apparent from the beginning of the pandemic. In this light, the solidity of the Italian National Health System must be highlighted, especially the hospitals, which are characterized by universal access.

Strengths and limitations

To our knowledge, this is the first study to evaluate the heterogeneity of the impact of the COVID-19 pandemic on metropolitan and inner areas of Italy. The classification criterion adopted by the National Strategy for the "Internal Areas" developed by the Territorial Cohesion Agency as of 2013 was used to achieve the aim of this study. This multidimensional classification of the territory is based on the education, healthcare, and public transportation services available. As we believed that a purely demographic and/or orographic criterion would not allow an analysis of the complex characteristics of the Italian territory, the classification system of inner areas made it possible to highlight those areas at greater risk of socioeconomic and healthcare vulnerability. The considerable heterogeneity in economic and social development throughout Italy strongly depends on easy access to services, which determine how attractive the population considers an area. Since the end of World War II, many inner areas have undergone an intense process of marginalization because of the scarcity of local services and of employment opportunities, thereby causing migration flows toward large cities. More recently, many of these areas have not exploited opportunities for economic valorization, fundamental to keeping local economies alive and attractive. To this can be added natural events, in particular earthquakes, which have further led to abandoning these areas. The result has been a progressive demographic decrease, a fall in employment, and an additional, progressive reduction in the quality and quantity of public services provided at the local level. This phenomenon has affected the country everywhere.

Nevertheless, the classification system adopted does not allow for a comparison with other studies because it is not validated, as are not most of the indicators of urbanization used in the literature (42). This is therefore a limitation of the study.

Furthermore, because the data available to us are aggregated, not individual-based, it is not possible to evaluate the effect of important determinants of health, for example, the presence of disease, lifestyle, and/or socioeconomic characteristics, the distribution of which throughout the national territory could account for some of the differences observed. Another aspect linked to this limitation is that the geographic categories considered in our study assume a homogenous risk within the areas. However, there may be some communities at greater risk than others, which would better explain geographic differences and would thus contribute to fine tuning targeting interventions.

Finally, we must acknowledge the possibility that the number of diagnoses of infection (especially when asymptomatic) may have been underestimated in the inner areas, especially in the early period of the pandemic, when access to diagnostic tests may have been more difficult in those areas due to the presences of fewer access points.

Conclusion

Our study highlights that the COVID-19 pandemic has also affected dimensions of health inequality that are not among those usually observed, with outcomes differing among the areas of residence and in the time periods of the pandemic examined. Of particular interest is the observation of a trend toward worse health outcomes in the inner areas as the pandemic has progressed, plausibly due to a lower vaccination coverage compared to that in metropolitan areas. This phenomenon underlines the need to strengthen the vaccination campaign in the inner areas of Italy. More generally, questions must be posed concerning the presence of factors of need, demand, and supply which may determine the differences in health of the populations of "metropolitan" and "inner" areas, more so in consideration of the fact that there is potentially greater vulnerability among the residents of inner areas, with the higher prevalence of chronic diseases such as diabetes and cardiovascular diseases.

Equity in access to healthcare in the inner areas of Italy and the need to strengthen primary prevention policies especially in these areas thus confirm the necessity of prioritizing healthcare planning that is oriented toward health equity.

Data availability statement

The data analyzed in this study is subject to the following licenses/restrictions: because of data sharing legal restrictions, the dataset including individual records cannot be made publicly available. However, aggregated data will be shared on reasonable request to the corresponding author (AP). Requests to access these datasets should be directed to AP, alessio.petrelli@inmp.it.

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

AP, AN, MV, AM-U, PP, and MF contributed to conception and design of the study. MV and MF organized the database. MV performed the statistical analysis. AP wrote the first draft of the manuscript. MV wrote sections of the manuscript. All authors contributed to manuscript revision, read, and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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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.2023.1143189/full#supplementary-material

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COVID-19 pandemic and the social determinants of health

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Hesitancy to receive a COVID-19 vaccination across sub-groups within the US population contributed to higher illness rates and deaths. Specifically, minority groups and those living in rural and remote areas are more vaccine-hesitant populations known to suffer from higher disparities in health. Identifying successful and replicable approaches to promoting vaccination within these subpopulations is critical to ensuring vaccination rates can be maximized in these vulnerable groups. In this paper, we present findings from the Mississippi Recognizing Important Vaccine & Education Resources (RIVERs) project, a multi-state effort to spread accurate information related to COVID-19 vaccinations using a variety of community and media-based methods as well as provide vaccinations. Vaccination rates for Black people in Mississippi exceeded those of White people, likely due to the concerted effort of regional health and community organizations. Propensity score matching is performed to test intervention styles using spatial and temporal data related to approximately 7,000 events across Mississippi and parts of Tennessee and publicly available data on vaccination rates and socio-economic data. We demonstrate that vaccination rates within the vulnerable groups may be closely related to misinformation being spread through local social networks and that interventions carried out by local leaders with high levels of local social capital are best at quashing misinformation at the local level. We recommend that policymakers consider the importance of local efforts as an effective tool in increasing vaccination rates in future pandemics.

KEYWORDS
COVID-19 vaccination, interventions, minority, community, health, rural

1. Introduction

The COVID-19 pandemic and the hesitancy of some population groups to get vaccinated have highlighted the importance of large public campaigns to promote vaccine uptake in the U.S. Public vaccination campaigns can take a variety of approaches, and different approaches can be tailored to fit regional or culturally unique subpopulations. Predicting which campaigns work best across regions and subpopulations will help ensure vaccination uptake occurs effectively. This paper presents findings from an analysis of a state-wide effort in Mississippi known as the RIVERs program. Despite Mississippi residents' high poverty rates and history of institutional distrust in government and healthcare, they increased their national ranking in vaccinations. The increase is partly due to an increase in African American vaccination rates, which overtook white Mississippians' vaccination rates over time (see Figure 1).

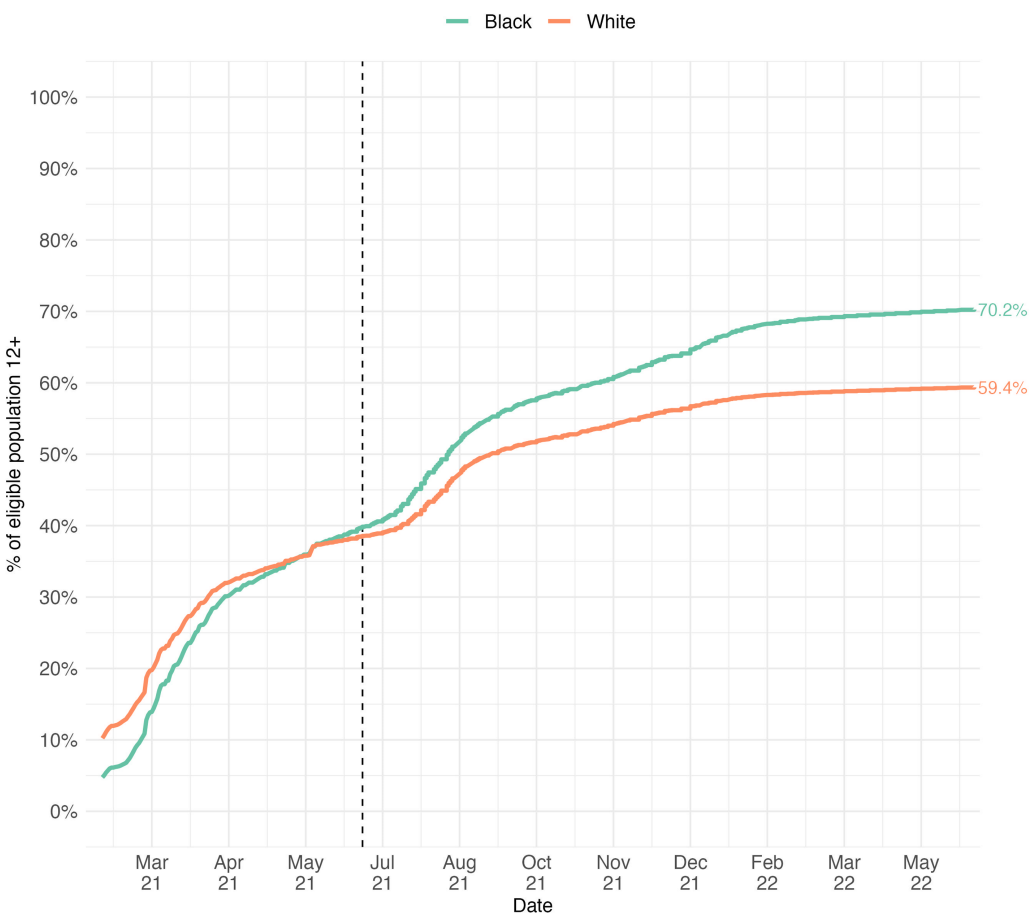

FIGURE 1
Daily cumulative growth in COVID-19 vaccinations by race in Mississippi. Black people vaccination rates overtake white people vaccination rates in summer 2021. Black dotted line highlights date of first RIVERs intervention in Mississippi.

1.1. Vaccinations and race

The impact of COVID-19 is not spread evenly across racial groups in the U.S. For example, studies conducted early in the pandemic noted that Non-Hispanic Black people had been negatively impacted at a notably higher rate when compared to other racial and ethnic groups. For instance, Price-Haywood et al. (1) racial differences in hospitalizations of COVID-19 patients in Louisiana and found that Black people comprised about 80% of the hospitalizations when only about 31% of them routinely received care from the hospital group. Gold et al. (2) found similar results in their study of COVID patients in March of 2020—over 80% of COVID-19 patients were non-Hispanic Black people, a number substantially higher than the proportion of non-Hispanic Black people living in the study area. A further study conducted in Chicago in the winter of 2020 found similar results; multivariate analysis of patient data on hospital admissions due to COVID-19 linked with social and demographic data revealed that being a Black person and older were the only statistically significant indicator of hospital admission (3). Racial differences in deaths due to COVID-19 were also identified during early periods of the pandemic, with Black Americans dying from the disease at disproportionally higher rates in the US (4).

A critical question from studies conducted early in the COVID-19 pandemic was to what extent exogenous social and economic characteristics impact the likelihood that a person ends up in the hospital due to contracting COVID-19. Raifman and Raifman (5) used data from the 2018 Risk Factor Surveillance System and modeled population risk factors for becoming ill with COVID-19 at a national level. They found that 33% of Black Americans were at a higher risk of becoming very ill with COVID-19 compared to only 27% of White Americans. Only American Indians were at higher risk than Black Americans, at 42%. The authors also found that low-income households were at higher risk and that the compounding nature of poverty, access to care, and lifestyle characteristics may impact sub-sets of the population at greater levels.

The reality that people living under undue economic burden suffer disproportionally from ill health is not new. Black Americans have an overall shorter life expectancy than non-

Hispanic White Americans. Some researchers theorize that the compounding effect of poor mental health coping strategies, environmental, social, and economic inequalities explain the drastic difference in life expectancies (6). Khazanchi et al. (7) argue that the disproportional number of minorities entering the hospital due to COVID-19 and the lack of any statistical differences in proportional outcomes between races once admitted to the hospital support their theory that "racism, not race" is to blame for the current inequities.

1.2. Geographic inequalities

People living in rural areas of the US face unique social and economic challenges that can make coping with the pandemic harder than their urban-dwelling counterparts. The rural economy is driven primarily by agriculture, forestry, and tourism. Jobs in these sectors are primarily seasonal, and many are informal (8), meaning that many job opportunities include any form of associated health insurance plan. Rural areas have consistently higher poverty rates than metro areas (9). Furthermore, people living in rural areas are often geographically isolated and have issues accessing health care services, lack reliable high-speed broadband access, and report high stigma associated with care, especially mental health services (10). The onset of the COVID-19 pandemic exacerbates the social and economic hardships in rural areas in the US. For instance, Mueller et al. (11) found that the economic shutdown and subsequent re-opening policies fueled an unemployment rate of about 9.74% in rural areas, compared to 7.40% nationally. These compiling factors are not dispersed equally across racial groups in rural areas, and there is evidence that racial differences in rural areas are disproportionally impacted. For instance, Henning-Smith et al. (12) found that rural counties in the US with the highest levels of non-Hispanic Black people or American Indian/Alaska Native (AI/AN) see the most significant proportion of premature death rates in the country.

There is clear evidence that the COVID-19 pandemic and subsequent lockdowns disproportionately impact minority populations and those living in rural areas of the US. Indeed, evidence also supports that minority populations living in rural areas experience a compounding effect and are at an even greater risk of ill effects of the virus and the social and economic disruptions caused by its reaction. The vaccine rollout, which began in late 2020, could reduce risks associated with contracting COVID-19 and reduce the racial inequalities in current COVID-19 death rates. However, recent research from residents in Arkansas suggests that vaccine hesitancy may be highest in non-Hispanic Black people due to fear and general mistrust (13).

1.3. RIVERs program & vaccination interventions

The RIVERs program is a consortium effort led by Delta Health Alliance in Stoneville, MS, to promote the uptake of COVID-19 vaccination in Mississippi and Tennessee. Program delivery occurred through various community and media interventions from June 2020 through May 2022. Program staff involved in community interventions participated in training on the science around vaccination and its impact on COVID-19 and training on working with local residents who may be vaccine-hesitant.

There are 25 categories of intervention types (see Table 1 for a complete list), each with a varying degree of community involvement. For example, some interventions took place at local libraries and involved discussion groups between program staff and local community members on the merits of vaccination; other interventions included mass media efforts featuring state-born celebrities that aired weekly on TV and social media platforms.

2. Method

A two-step research design is used to determine which categories of community interventions are associated with more people becoming vaccinated. The first step is to create a control group of counties that received no program interventions. The second step is to determine which interventions are associated with significant changes in vaccination rates between each treatment county and its matched control county.

2.1. Creating a control group

Matching is often used in the social sciences to identify sub-populations that can act as a comparable control group in observational studies. Using matching algorithms to create control groups is preferred over identifying a purely randomized control group in observational studies because it allows for any biased or spurious covariates to be controlled for during the matching process (14). This approach is particularly useful to this research due to the previously detailed social and

TABLE 1 Recoded intervention categories and methods.

Recoded category	Original category
Vaccine access	This is a vaccine delivery site; Transportation/getting to a vaccine delivery site
Traditional media	A radio spot; A tv spot
Visiting community	Visiting a community-based recreation center; Visiting a church, temple, or other religious site/building; Visiting a local school, college, or a community learning center; Visiting an lgbtq community resource center; A community fair or event
Digital impression	Jumbotron; A social media site
Personal communication	Text message; Door-to-door outreach; Door hangers; A training session; Other form of in-person interaction not listed here; ^a telephone call; Focus group; Email
Virtual	A virtual town hall; A community website, blog, or web-based tool about covid-19 vaccines; A webinar
Information flyers	Flyers; Billboards or other types of posters/signs around the community; Educational and/or informational fliers about covid-19 vaccines; ^general information on covid-19 vaccines; Mail

environmental factors that are believed to influence people to receive a COVID-19 vaccination. The *MatchIt* package (15) in the R programming language (16) is used to perform matching. The Mahalanobis distance approach is used, rather than propensity scores, due to relatively few covariates and all covariate's approximate normal distribution (17).

2.1.1. Identifying co-variates

Treatment counties include only counties in Mississippi that received some community intervention during the RIVERs program. For data consistency, the five counties receiving Tennessee interventions are not included.

All counties in the US except those in Mississippi and the five program counties in Tennessee are included in the pool of potential matches. Variable selection is based on previously mentioned literature and all data included are from the US Census Bureau published in 2020 except for the percent of the county that is classified as rural. The US Census has not yet published data on percent of each county classified as rural as of this publication. Therefore, percent of county classified as rural according to the US Census in 2010. Covariate variables are:

- Percent of county classified as African American alone;
- Median household income by county;
- Percent of county aged 65 or older;
- County population; and,
- Percent of county classified as rural.

2.2. Identifying intervention impact

The RIVERs program conducted about 7,200 interventions from July 2, 2021, to May 21, 2022. Interventions were categorized according to a list of 25 potential delivery methods. An intervention could be categorized into more than one category. Each intervention category has been recoded to fit the following categories based on the type of activity: visiting community, personal communication, info-flyers, digital impression, vaccine access, traditional media, and virtual.

Vaccination totals by county come from the Centers for Disease Control and Prevention's website and data portal. Daily vaccination totals were merged with daily intervention data for each county. The date of the first and last intervention for each county; the total number of each intervention type were then calculated for each county; then, the change in vaccination totals for each treatment county and its matching control county is calculated. Finally, the difference between a change in the vaccination total of each treatment county and its matching control county is calculated. This data is then merged with the data of covariates mentioned above.

The resulting database contains a column indicating the difference in treatment and control vaccination totals and count data on the total number of interventions for each category. An Ordinary Least Squares (OLS) model is produced using difference in vaccination totals between treatment and control counties as the dependent variable. Equation 1 details the full model, and results are presented in Table 3.

$$\begin{aligned}\Delta\, Vaccination &= \alpha + \beta_1(Householdincome) + \beta_2(Blackpeoplealone) \\ &\quad + \beta_3(Percentcountyrural) + \beta_4(Digitalimpression) \\ &\quad + \beta_5(\text{Flyers}) + \beta_6(\text{Personalcommunication}) \\ &\quad + \beta_7(Virtualmeeting) + \beta_8(Visitcommunitycenter) \\ &\quad + \beta_9(Traditionalmedia) + \epsilon\end{aligned} \tag{1}$$

3. Results

3.1. Bivariate correlations

Bivariate Pearson correlations are found in Table 2. All covariates are statistically associated vaccination numbers in the treatment counties. Percent of Black residents, and the percent of a county with a bachelors degree or higher are positively correlated with vaccination numbers while household income, age and percent rural are negatively associated with vaccination numbers. Percent rural is also negatively associated with vaccination numbers in control counties as well.

3.2. Matching results

Matched results have a standardized mean difference (SMD) close to zero, indicating a good balance in covariates. All but one matched county comes from a southern state, and about 42.7% of matched counties come states that border Mississippi.

TABLE 2 Correlations: changes in vaccination and socio-demograpnics for treatment and control groups.

Variable	Treatment	Control
Percent of county that classifed as black people alone	0.274*	0.107
Median household income by county	−0.269*	0.008
Percent of county aged 65 and older	−0.230*	−0.183
Percent of county with a bachelors degree or higher	0.277*	0.068
Percent of county classified as rural	−0.372***	−0.277*

*$p \geq 0.1$; **$p \geq 0.05$; ***$p \geq 0.01$.

TABLE 3 OLS: DP is the difference in change in vaccination of treatment and control counties.

Term	Estimate	Std_Error	Statistic	Prob
Intecept	−13,470.13	3371.464	−3.995	0.0***
Percent African American	7,330.09	3682.115	1.991	0.0503*
Percent county rural	10,705.07	3123.975	3.427	0.001***
Digital impressions	−1.37	0.367	−3.728	0.000***
Flyers	0.00	0.120	−0.016	0.987
In-person communication	0.30	0.151	1.989	0.0505*
Virtual meeting	−0.23	1.004	−0.225	0.823
Visit community center	−0.48	0.281	−1.690	0.095*
Traditional media	0.10	0.049	2.135	0.036**

R^2 0.465; Adj. R^2 0.4064.
*$p \geq 0.1$; **$p \geq 0.05$; ***$p \geq 0.01$.

3.3. OLS results

Examing multicollinearity revealed a high degree of correlation (−0.560, Pearson) between Percent African American and Household income for treatment counties. This was only slightly less for control counties (−0.538, Pearson). We therefore removed this variable from the multi-variate model. OLS model results, shown in Table 3 has an adjusted R-squared value of 0.4064, suggesting a good fit relative to other social science research models (18).

$$\begin{aligned}\Delta\ Vaccination = &-13470.13 + 7330.09(PercentAfricanAmerican)\\ &+ 10705.07(Percentcountyrural)\\ &- 1.37(DigitalImpressions) + 0(Flyers)\\ &+ 0.3(In-personCommunication)\\ &- 0.23(VirtualMeeting)\\ &- 0.48(VisitCommunityCenter)\\ &+ 0.1(TraditionalMedia)\end{aligned}$$

Model coefficients suggest that personal communication and traditional media approaches have a positive and statistically significant association with increased numbers of people vaccinated in treatment counties compared to control counties. Furthermore, higher digital impressions are statistically associated with lower numbers of vaccinations in treatment counties compared to control counties. No other variables were found to be statistically significant.

4. Discussion

For the past two years, COVID-19 represents the third leading cause of death in the United States, with more than 350,000 deaths per year (CDC FastStats). COVID-19 related illnesses, hospitalizations, and deaths are not distributed evenly. Pre-existing social and economic disparities in these outcomes have been exacerbated, as evidenced in a plethora of studies in the academic literature and popular media (cite several of the studies you have already cited maybe even a couple new ones). In nearly every measurable health, social, and economic outcome, Mississippi ranks at or near the bottom, making the state the ultimate petri dish for negative COVID-19 related outcomes. Regarding specific COVID-19 outcomes, in 2020, Mississippi had the highest per capita death rate in the nation at 1,138.7 deaths per 100,000 (KFF). In comparison, the U.S. average was 835.4 per 100,000. At the beginning of the RIVERs project, Mississippi had the lowest vaccination rate in the county, with less than one-third of residents having received at least one dose of the vaccine. The U.S., however, exhibited a rate of 46.2% (KFF). Although the state has experienced its share of struggles, the RIVERs project has demonstrated a remarkable success for the most vulnerable citizens of a state rife with every layer of disadvantage.

Current data shows that Mississippi is the only state in the U.S. with high levels of rural poverty where the Black population has higher rates of COVID-19 vaccinations than the white population. At the close of the RIVERs project in April of 2022, 69.6% of Black people had received their first vaccination, compared to only 58.9% of White people. In addition, Black people continued to widen the gap of becoming fully vaccinated over White peple, a 9.0% difference (62.4% vs 53.4%). The improvement in vaccine uptake appears to coincide with the start of the RIVERs program. Readers should note that we cannot definitively assign causality due to the myriad policy changes and community efforts unrelated to RIVERs that likely contributed to the increased uptake of vaccinations.

However, these results are evidence of the power of community engagement and optimization of local leadership being leveraged to educate community members and successfully counteract misinformation, while of course also protecting the most vulnerable citizens. The concerted efforts in Mississippi are proven to be effective given the lack of success in other states and counties with comparable social and economic circumstances. Candidly, the positive effects of the RIVERs project in Mississippi should serve as a model for positive public health intervention outcomes in other communities across the nation both now and in the future. Success in a place with every conceivable built-in disadvantage in society suggests that success should be achievable elsewhere as well. Policy makers, health practitioners, and local leaders should consider greater emphasis and investment in community level initiatives in future public health crises, either as a primary mechanism or in conjunction with other proven interventions and methodologies.

5. Limitations

Due to data being aggregated to the county-level, a sample of 82 yields a corresponding low statistical power. This is a limitation of our study and should be considered in replicated studies or drawing policy conclusions. Readers should note that alpha levels for significant testing begin at 0.10.

This study also lacks important contextual considerations as controlling covariates, mainly the likely impact that vaccination access (out-with of that offered by the RIVERs program as an event) and any local policies regarding vaccination status. Future studies may benefit from including local access to vaccinations and policies to better parse the impact of local vaccination efforts.

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 Delta State University IRB. Written informed consent for participation was not required for this study in

accordance with the national legislation and the institutional requirements.

Author contributions

JM is first author and all other authors contributed equally. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Effects of social factors on the COVID-19 cases and its evolution in Hubei, China

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Introduction: In order to study the impact of social factors on the evolution of the epidemic, this paper takes the COVID-19 in Hubei Province of China as an example to study the impact of social factors such as the permanent population, universities, hospitals, the distance between Wuhan seafood market and 17 cities in Hubei Province, and the distribution of medical supplies on the COVID-19. This is of great significance for helping to develop effective prevention and control measures and response strategies, ensuring public health and social stability.

Methods: Time series regression analysis is used to study the impact of various factors on the epidemic situation, multidimensional scale analysis is used to assess the differences among provinces, and Almon polynomial is used to study the lag effect of the impact.

Results: We found that these cities can be divided into three groups based on the number of confirmed cases and the time course data of the cases. The results verify that these factors have a great impact on the evolution of the COVID-19.

Discussion: With the increase in the number of universities, the number of confirmed cases and new cases has significantly increased. With the increase in population density, the number of new cases has significantly increased. In addition, the farther away from the Wuhan seafood market, the fewer confirmed cases. It is worth noting that the insufficient increase in medical supplies in some cities still leads to a significant increase in new cases. This impact is regional, and their lag periods are also different. Through the comparison with Guangdong Province, it is concluded that social factors will affect COVID-19. Overall, promoting the construction of medical schools and ensuring the reasonable distribution of medical supplies is crucial as it can effectively assist decision-making.

KEYWORDS

evolution of the COVID-19, social factors, time-series data, lag period, linear model, statistical analysis

1. Introduction

As of May 20, 2022, according to reports, 523,431,796 cases of COVID-19 have been confirmed worldwide, 495,381,216 cases have been cured and discharged from hospital, and 6,281,384 people have died. COVID-19 had affected our lives significantly. COVID-19 had a great impact on the British beef and sheep supply chain—the overnight closure of hospitality and catering and the redirection of supplies to the retail sector, and the public health and economic system faced serious negative effects (1, 2). The prevention and control of COVID-19 was still grim.

Social factors played a decisive role in the prevention and control of infectious diseases (3). As early as 2005, WHO defined the social determinants of health as follows: in addition to those

TABLE 1 Research on influencing factors of COVID-19.

	Method	Related factors	Subjects	Author (year)
Economic factors	LR	GDP; race	Cities with a population of more than 1 million or metropolitan areas	Cao et al. (4)
	LRM	Unemployment; poverty population density	5,698 patients at Michigan Medical University	Gu et al. (5)
	RMP	SVI	U.S.A	Freese et al. (6)
Living environment factors	ANN	Social distancing (lockdown); Density of the population; Urban population; Gender ratio	Globality	Sharma Asha (7)
	QR	Obesity; population over the age of 65	184 countries	Ashish Upadhyaya (8)
	LR	Geographical location; temperature; humidity; wind speed	Cities or metropolitan areas with a population of more than 1 million	Cao et al. (4)
	Poisson, ZIP, ZINB	Temperature; humidity; wind speed	Kingdom of Saudi Arabia	Anam (9)
	Partial Correlation, Linear Mixing	Temperature factors at different income levels	Globality	Mizanur et al. (10)
	LR	Number of McDonald's and fitness centers	New Jersey	Amaratunga (11)
	GWR	Air pollutants; meteorological factors	China	Pei Lin et al. (12)
	Regression	Sunrise distance; effective reproduction number	Switzerland	Lison et al. (13)
	LR	Latitude; longitude; temperature	Cities with a population of more than 1 million or metropolitan areas	Cao et al. (4)
	ITSA	Social distance	28 European countries	Vokó and Pitter (14)
	EM	Existing medical conditions; lack of water	Mexico	Revollo-Fernández et al. (19)
Medical factors	LRB	Coronary heart disease (CHD); cancer; antiviral drugs	Kurdistan Province	Eghbal (15)
	RAC	Age; sex; symptoms and hospitalization	In Regensburg, Germany	Lampl et al. (16)
	OLS; RCS	Number of inpatients in an intensive care unit	Italy	Lorenzoni et al. (18)

SVI, Social Vulnerability Index; QR, Quantile Regression; RCS, Restricted Cubic Spline; ITSA, Interrupted Time Series Analysis; LR, Logistic Regression; MLR, Multivariable Logistic Regression; MPR, Multivariable Poisson Regression; BLR, Binary Logistic Regression; OLS, Ordinary Least Square; ANN, Artificial Neural Network; ZIP, Zero-Inflated Poisson; ZINB, Zero-Inflated Negative-Binomial; GWR, Geographically Weighted Regression; EM, Econometric Model; RAC, Retrospective Analysis of a Cohort.

factors that directly lead to disease, the living and working environment and other factors that affect health are determined by people's social status and resources. At the beginning of the outbreak of COVID-19, a serious shortage of medical resources occurred in Wuhan, Hubei Province. On January 31, 2020, Hubei Daily reported that there were only two specialized infectious disease hospitals in Wuhan with just less than 1,000 beds available, and medical materials were stretched. However, the influencing mechanisms of social factors on the evolution of COVID-19 were still obscure. In this paper, we chose Hubei as the case to investigate the impact of social factors on COVID-19. Here the social factors refer to the economic factors, the living environment, and medical factors. Economic factors imply economic development, measured by GDP, the poverty rate, and other factors. The living environment factors include temperature and social distance. The medical factors represent the medical condition of the research object, including the number of hospitals and the number of medical materials.

The research in this paper aims to answer the following three questions (RQs):

RQ1: Which of the above factors uniquely affected the evolution of COVID-19? How did they affect the cases of COVID-19?

RQ2: What was the impact of time-series medical supplies on COVID-19?

RQ3: Through the analysis of the investigated factors, what suggestions could be brought to the policy-making for the prevention and control of COVID-19?

So far, some scholars have conducted in-depth research on the impact factors of COVID-19. We have combed the recent relevant literature and divided these factors into three categories: medical resources, social variables, and environmental factors, as shown in Table 1.

Economic and living conditions had been demonstrated to affect the evolution and development of COVID-19 (4). The urban ratio, population density Sharma (7), temperature, humidity, and wind speed affected the evolution and the number of COVID-19 (4, 9). In addition, in economies with different income levels, the impact of temperature on COVID-19 mortality was different. A warm climate may reduce mortality in high-income economies, but in low-income and middle-income countries, high daily temperature changes may increase mortality (10). The increase in the number of McDonald's led to a decrease in the number of cases and deaths in New Jersey, while the number of fitness centers was related to the increase in the number of cases and deaths (11). Vokó and Pitter used interruption time series analysis to study the impact of social distance on COVID-19, identified the most likely change-points in 28 European countries, and confirmed that the "stay-at-home" national policy had made a meaningful

TABLE 2 Part of COVID-19 data in Wuhan in 2020.

Date	Confirm	Dead	Heal	Suspect	confirm_add
02.21	45,346	1,684	6,214	0	319
02.22	45,660	1,774	7,206	0	314
02.23	46,201	1,856	8,171	0	541
02.24	46,607	1,987	8,946	0	348
02.25	47,071	2,043	10,337	0	464
02.26	47,441	2,085	11,793	0	370
02.27	47,824	2,104	13,328	0	383
02.28	48,137	2,132	15,826	0	313
02.29	48,557	2,169	17,552	0	420
03.01	49,122	2,195	19,227	0	565

contribution to the suppression of the European COVID-19 (14). There was a direct relationship between the rapid growth of inpatients in Intensive Care Units (ICUs) in Italy and mortality. The increase in daily ICU admissions resulted in a significant increase in mortality after 3, 7, and 14 days Lorenzoni et al. (18).

The above literature mainly analyzed the impact of population density, GDP, temperature, wind speed, social distance, number of inpatients, and other factors on COVID-19 through the Artificial Neural Network, Time Series Analysis, Logistic Regression, Geographical Weight, and other regression models. The review of the existing technology showed that economic, environmental, and medical factors have a direct impact on COVID-19. Given the importance of the influencing mechanisms of special social factors on the evolution of COVID-19, we studied how the social factors affected the evolution of COVID-19 in the cities of Hubei Province in China. We selected economic factors (GDP), environmental factors (the number of permanent residents, the number of universities, the distance to the South China Seafood Market), and medical factors (the number of hospitals, and the distribution of medical materials) as research variables. This study discussed the relationship between COVID-19 and the above factors through the regression analysis and analyzed the relationship between the distribution of medical materials in Hubei Province in March 2020 and the number of COVID-19 cases through time series.

This work contributed in three ways. Firstly, through discussion and analysis, the importance of the influencing factors in the evolution of COVID-19 in Hubei Province was proposed. Secondly, the impact of medical materials on COVID-19 and their lag periods were deeply analyzed, and a thought-provoking conclusion was found that the rational allocation of medical materials was of great importance for policy-making. More importantly, this paper judged the rationality of allocation of medical material through the above results, put forward targeted suggestions, minimized the waste of medical materials, and provided policy support for the government in the distribution of medical material and epidemic prevention and control.

The rest of the paper was structured as follows. In section "Methods", we discussed the data sources and statistical methods used. In section "Results", we gave the test results, evaluated the model, then discussed it in section "Discussion", and draw a conclusion in section "Conclusions".

2. Methods

2.1. Data source

2.1.1. Case data

We collected the data of confirmed, dead, cured, suspected and new increased cases(confirm_add) in 17 cities such as Wuhan and Yichang, Hubei Province from January 21 to June 1 (15).[1] Part of the data in Wuhan were shown in Table 2.

2.1.2. Static social data

The data of the permanent resident population were from the statistical yearbook of Hubei Province in 2020[2]; the distance to the seafood market in Wuhan came from the distance calculation of the Gaude map; the number of colleges and universities came from the list of all colleges and universities in Hubei. Data were shown in Table 3.

2.1.3. Time series data of medical materials

The data on medical materials were from the announcement of distribution of protective materials in medical institutions in Hubei Province.[3] Data were shown in Table 4.

2.2. Statistical analysis

In this study, we analyzed the total number of confirmed cases and time course data. The form of time course data were (T_i, Y_{ij}), where t_i was the date ($i = 1, \ldots, m$), and T_{ij} was the total number of cases in City j up to the time t_i.

2.2.1. Analysis of the number of cases

Since the number of cases was related to the population, this paper also used the proportion of cases in the county as the response variable, $Y_j = T_{ij} / P_j$. In order to investigate the relationship between added cases and factors, it also used the added case A_{ij}, $A_{ij} = T_{(i+1)j} - T_{ij}$, where P_j was the population of City j. Due to the correlation between variables, this paper ran a linear regression model

1 https://news.qq.com/zt2020/page/feiyan.htm#/
2 https://www.hubei.gov.cn/
3 http://tjj.hubei.gov.cn/

TABLE 3 Data on social factors of each city.

	University/Institute	Permanent resident population/10,000	Hospital/Institute	Distance/km
Wuhan	86	1121.2	70	4.6
Xiaogan	4	492.1	31	44.1
Jingmen	2	289.75	12	201
Jingzhou	7	557.01	39	194
Huanggang	4	633.3	21	396.2
Ezhou	1	105.97	18	65.9
Yichang	3	413.79	24	284.7
Enshi	3	339	93	449.3
Suizhou	1	222.1	54	146.2
Xiantao	1	114.01	26	145.1
Huangshi	4	247.17	15	85.2
Xiangyang	4	568	98	259.2
Qianjiang	1	96.61	21	132.8
Shiyan	6	339.8	84	390.4
Shennongjia	0	7.61	1	388.9
Xianning	2	254.84	46	83.3
Tianmen	1	124.74	25	106.6

TABLE 4 Data of medical materials in Wuhan in 2020.

Date	Medical protective clothing (MPC)	N95 face-mask (N95)	Medical surgical mask (MSM)	Medical protective face shield (MPFS)	Medical isolation gown (MIG)
02.21	14,971	15,330	31,349	1906	2,862
02.22	13,209	20,574	40,473	2,207	10,756
02.23	15,604	19,860	576,910	4,416	9,825
02.24	16,926	23,077	830,940	4,356	9,455
02.25	16,508	31,664	78,350	4,383	8,382
02.26	16,093	29,082	909,290	4,436	7,277
02.27	13,574	27,606	603,260	4,467	8,006
02.28	11,636	25,970	496,190	2,540	3,652
02.29	13,385	19,776	474,580	4,530	5,453
03.01	14,971	15,330	31,349	1906	2,862

and then selected variables by reverse stepwise regression fitting. By the way, we first standardized the data to the range of 0 to 1 to avoid the influence of dimension.

2.2.2. Explanatory variables

The explanatory variables of this study included the number of colleges x_1, the resident population x_2, the number of hospitals x_3, and the distance from the seafood market in Wuhan x_4.

In particular, the number of hospitals x_3 was closely related to the population x_2. Collinearity between independent variables would lead to invalid model construction and loss of effectiveness of regression fitting. To avoid this effect, the number of hospitals was divided by the total population to make the variables independent of each other. The matrices of scatter plots of the two datasets were shown in "Appendix A," in which the variables were relatively independent.

2.2.3. Data visualization

The visualization of COVID-19 data in Hubei Province could be drawn, as shown in Figure 1.

Embedding the data into the map of Hubei Province could realize the functions of viewing the specific quantity and changing the visual level through the mouse click, scroll wheel, suspend, and other operations, to avoid the problems of data loss and overlap. Figure 1 used color to distinguish the severity of COVID-19. According to the geographical distribution of the original diagnosis data, we could view the dynamic change trend and more intuitively analyze the evolution law of COVID-19 in Hubei Province.

2.2.4. Dissimilarity matrix

The cumulative confirmed cases in cities in Hubei province continued to grow. In the early stage of COVID-19, the cases of

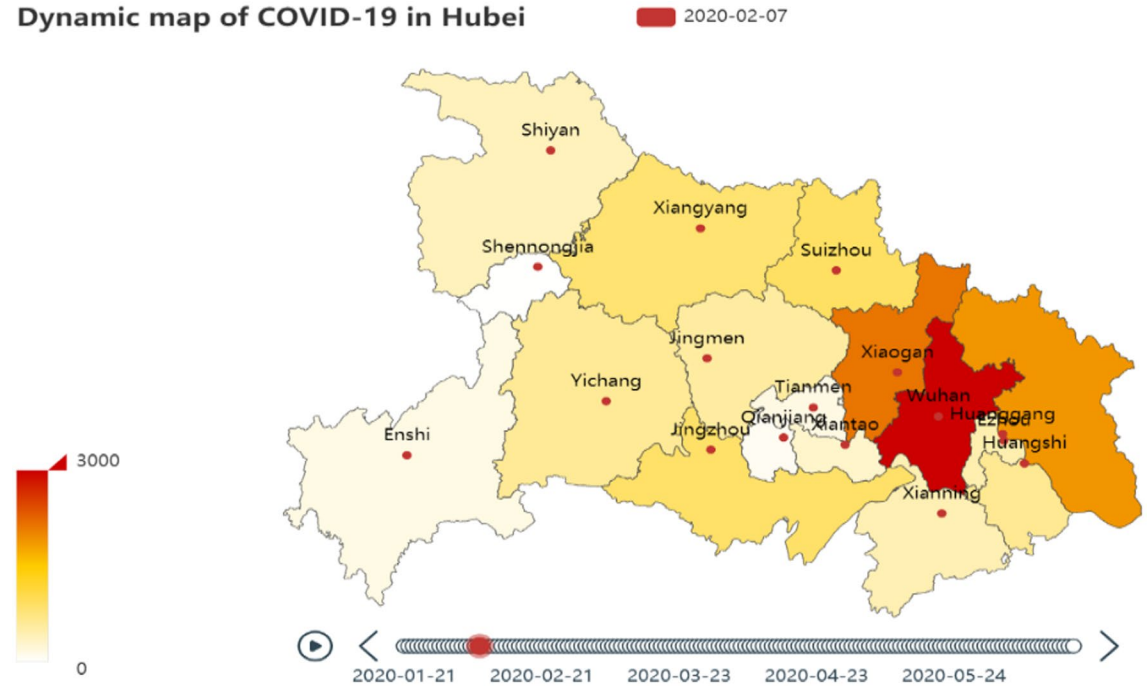

FIGURE 1
Dynamic map of COVID-19 in Hubei Province.

cities increased exponentially, especially in Wuhan. Since then, the cumulative confirmed case curve of cities showed a horizontal state, indicating that the prevention and control of COVID-19 in Hubei Province had achieved remarkable results.

The time process data were shown in Figure 2. We used the area between city curves to define the difference D_{AB} between City A and City B, using the following formula $D_{AB} = \sum_i |y_{iA} - y_{iB}| \delta_i$.

In this article, the horizontal axis represented the number of days, so $\delta_i = 1$.

2.2.5. Multidimensional scaling

Multidimensional scaling (MDS) can be used to find a set of points $\{p_A\}$, so that the Euclidean distance between p_A and p_B is close to D_{AB}. Since the first eigenvector of MDS can explain a large part of the differences between cities, it is reasonable to believe that the value $\{p_A\}$ along the eigenvector carries the major information about the differences between counties. These values are expressed as $\{p_A^*\}$, then used as response variables and modeled according to explanatory variables. In this study, multidimensional scaling (MDS) generated the point set in Figure 3.

2.3. Time series data analysis

The explanatory variables included in this study include MPC x_5, N95 x_6, MSM x_7, MPFS x_8 and MIG x_9.

Firstly, the ADF test was selected to determine the stationarity of the sequence, and a differential method was used to realize the sequence stationarity of the non-stationary sequence. To alleviate the influence of heteroscedasticity, this paper reduces the scale of variables by taking the logarithm of time series. In order to avoid the quantity being 0, the model was constructed as follows:

$$\ln(1+y) = C + \beta_1 \ln(1+x_5) + \beta_2 \ln(1+x_6) + \beta_3 \ln(1+x_7) + \beta_4 \ln(1+x_8) + \beta_5 \ln(1+x_9) + \delta$$

The article then used the Almon method to calculate the lag period in the impact of medical supplies on new cases.

3. Results

3.1. Analysis of social factors

The regression results were shown in Table 5, where column T represented the total number of cases, column A represented the number of new cases, column T/P and column A/P represented the proportion excluding the impact of population. The effect was almost the same. The most important factor was the number of universities. As expected, with the increase of universities, the total number of cases and new cases have raised significantly. With the accretion of population density, the number of new cases increased significantly. Surprisingly, the data collected showed that the number of hospitals did not significantly affect the number of cases. On the other hand, the difference results of the proportion of cases (column T/P and column A/P) were similar to the results of the total number of cases (column T and column A), but the population had a great difference between column A and column A/P, indicating that the proportion of newly added cases increases significantly with the

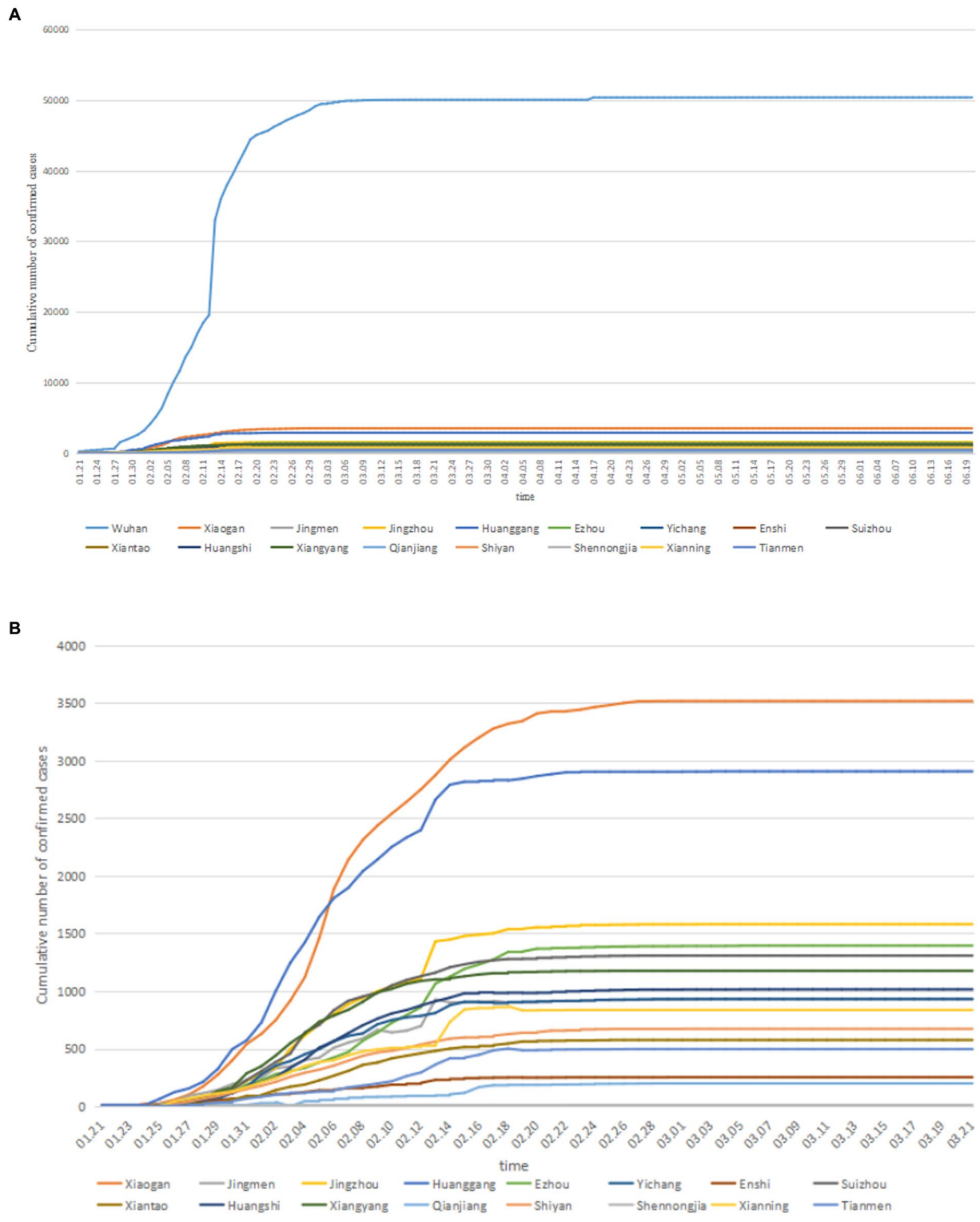

FIGURE 2
COVID-19 in Hubei **(A)** the trend map; **(B)** partial drawing (excluding Wuhan).

accretion of population density. GDP has no significant impact on the evolution of COVID-19 in cities of Hubei Province. It was worth noting that the distance from the seafood market in South China had a significant impact on the total number of cases, but has no significant impact on added cases.

3.2. Time series analysis of medical factors

The regression results of time series were shown in Table 6. The time series of cumulative medical factors had different effects on new cases in each province. Among them, Xiaogan and Enshi were not

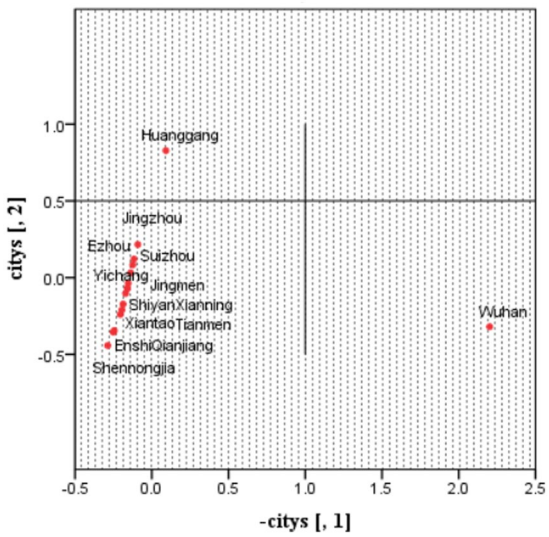

FIGURE 3
Scatter plots of MDS for the dissimilarity matrix relevant to the original case data.

TABLE 5 Regression results using the data.

Variables	T	T/P	A	A/P
University	0.06&	0.05&	0.17&	0.02&
Population	−0.01	−0.04	−0.12^	0.02#
Hospital/p	−0.29	−0.19	−0.76	−0.16
Distance	−0.04#	−0.01&		
GDP		0.04	−0.07	0.02

Significant codes: 0 &, 0.001 ^, 0.01 $, 0.05 #, 0.10.

TABLE 6 Time series regression results of accumulated medical materials.

Variables	MPC	N95	MSM	MPFS	MIG
Wuhan	−8.49$	3.29	1.44&	−0.02	0.53&
Xiangyang	−0.31	0.35	−0.39$	0.30	−0.16
Yichang	−1.38#	−0.40	0.40#	2.93$	−1.69$
Huangshi	0.69#	0.66	0.23#	1	0.57&
Shiyan	2.05&	−1.83&	0.5#	−0.39	−0.72$
Jingzhou	0.62	−1.39#	−0.08	−0.11	0.44
Jingmen	1.08#	−1.35	0.38	−0.28	−0.24
Ezhou	−1.48#	2.02#	0.31	−0.71	−0.65
Xiaogan	−0.79	−1.99	0.42	0.45	0.77
Huanggang	1.04	0.48	−0.3#	−1.4	−0.06
Xianning	0.36#	0.01	−0.28&	−1.4&	1.19&
Suizhou	0.40	−1.70&	−0.07	0.58#	0.39
Enshi	0.52	−0.03	−0.11	−0.79	0.22
Xiantao	−1.45$	1.47	−0.38	−0.46	0.61
Tianmen	−0.45	0.59	−0.38$	0.87$	−0.72
Qianjiang	0.29	−1.67&	0.18#	1.33&	−0.37#
Shennongjia	0.05	−0.24	−0.18&	0.06	0.37$

Significant codes: 0 &, 0.001 ^, 0.01 $, 0.05 #, 0.10.

sensitive to the allocation of medical resources, and other factors still need to be solved.

The new cases in Wuhan, Yichang, Shiyan, Ezhou, and Xiantao decreased significantly with the increase of MPC; The number of new cases in Shiyan, Jingzhou, Suizhou, and Qianjiang decreased significantly due to N95; MSM had a significant effect on new cases such as Xiangyang, Huanggang, Xianning, Tianmen, and Shennongjia; Xianning was significantly affected by MPFS; The influential factor in new cases in Yichang, Shiyan, and Qianjiang was MIG.

It was not difficult to find that the accretion of medical factors would mostly lead to the reduction of new cases. However, we may also see that the increase in medical factors will mainly lead to the reduction of new cases, which indicated that there are still problems in the supply of medical materials. On March 6, 2020, Sohu News released that the gap in medical materials in Hubei is still large (20). Our research results also reflect this situation. For example, in Huangshi, Jingmen, Xianning, and other places, MPC materials are seriously insufficient, and new cases still increase significantly.

3.3. Comparison with Guangdong Province

In order to explore the impact of social factors on COVID-19 in other regions, this paper selects Guangdong Province for a comparative study. The research method is the same as above. The independent variable is removed from the distance, and x1, x2, x3, and x5 are selected to represent the number of university, population, the number of hospital, GDP. Regression results were as shown in Table 7.

The comparison showed that the GDP of Guangdong Province has a significant impact on the total number of cases and the proportion of new cases. The reason is that the higher the GDP, the better the economic situation of the region, the more economic exchanges, the higher the risk of infection, which will lead to an increase in the number of cases. In addition, the more universities and population in Guangdong Province, the fewer new cases, indicating that the prevention and control measures in Guangdong Province effectively controlled the spread of COVID-19 at the beginning of the epidemic. By the way, new research showed that in (15), while Guangdong successfully controlled the COVID-19 with Non Drug Interventions (NPI), it also "accidentally" achieved the containment effect of 39 other statutory infectious diseases, with the total number of cases falling 65.6% from the expected level, reducing the incidence of nearly one million people (17).

The comparison between Guangdong Province and Hubei Province showed that social factors will have an impact on COVID-19, but due to regional differences, the degree of impact is also different.

TABLE 7 Regression result data of Guangdong Province.

Variables	T	T/P	A	A/P
University	0.043	0.519	−0.235^	−0.112
Population	−4.66^	−1.64	−0.523^	−1.026
Hospital/p	0.079	−0.79	0.186#	−0.098
GDP	1.32&	1.56^	1.457&	1.742&

Significant codes: 0 &, 0.001 ^, 0.01 $, 0.05 #, 0.10.

TABLE 8 Region and its lag period.

Region	Lag period (day)
Wuhan	1
Jingmen	3
Suizhou	4
Qianjiang	3

3.4. Lag period

For further exploration, this paper used the Almon polynomial to study the lag effect of time series of medical materials on the number of new cases. The areas with lag period were shown in Table 8.

4. Discussion

We may expect that the high density of population and universities means more personnel mobility, which was the main way of virus transmission. In addition, the farther the distance, the fewer confirmed cases. The more medical supplies, the fewer new cases. However, the results showed that the impact of the number of hospitals was not important. In addition, the distribution of some medical materials had a very different impact on the number of new cases in each city. With the accretion of materials, the number of new cases gradually decreased. However, the data showed that the supply of medical materials in some cities is insufficient, and the number of new cases was still increasing significantly. Another explanation may be that with the increase in the supply of medical surgical masks, the burden of medical waste increased, and improper treatment of medical materials led to more infections. To sum up, we found that the evolution of COVID-19 was affected by some social factors, which may help in healthcare policy-making. At the same time, the rational distribution of medical materials must be ensured.

5. Conclusion

This study investigated the social factors affecting confirmed cases of COVID-19 in 17 cities of Hubei Province. We found that the city could be divided into three groups according to the number of confirmed cases and the time course of cases. According to the research results, some suggestions of public health policy could be put forward.

For medical materials, this paper put forward the following suggestions: in order to carry out the prevention and control of COVID-19, the rational allocation of various medical materials would be of great benefit, but we also need to pay attention to improving protective measures in hospital, doing a good job in isolation and preventing accidents. Irregular handling of medical materials could also lead to infection. Hospital managers should properly deal with medical waste by improving the quality of employees. At the same time, the supply of medical materials should also consider their lag effects, reduce the waste of medical materials and ensure the maximization of the utility of materials. Therefore, it was particularly important to understand the supply, transportation, and treatment of medical materials.

From the perspective of the number of "population" and "universities," the suggestions put forward in this paper were as follows: first, do a good job in the management and control of colleges and universities, and reduce the flow of students outside winter vacation and summer vacation. Second, promote the construction of medical schools. At present, there were few independent medical schools. The development of most urban medical schools depended on the existing local comprehensive universities. The establishment of medical colleges and departments and medical schools could greatly improve the local medical resources and strength. For some cities with a large population, especially Huanggang City, which had a registered population of more than 5 million, there were only 21 hospitals. Its medical strength was quite weak and needs to be strengthened urgently. For some small and medium-sized cities in Wuhan city circle, it was very important to rely on Wuhan's rich medical college resources, strengthen cooperation, speed up construction and improve medical capacity.

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.

Author contributions

SY and LD: conceptualization and validation. SY: methodology and writing—original draft preparation. LD: resources, writing—review and editing, supervision, project administration, and funding acquisition. DM: data collection and collation. All authors have read and agreed to the published version of the manuscript.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

Publisher's note

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Appendix A

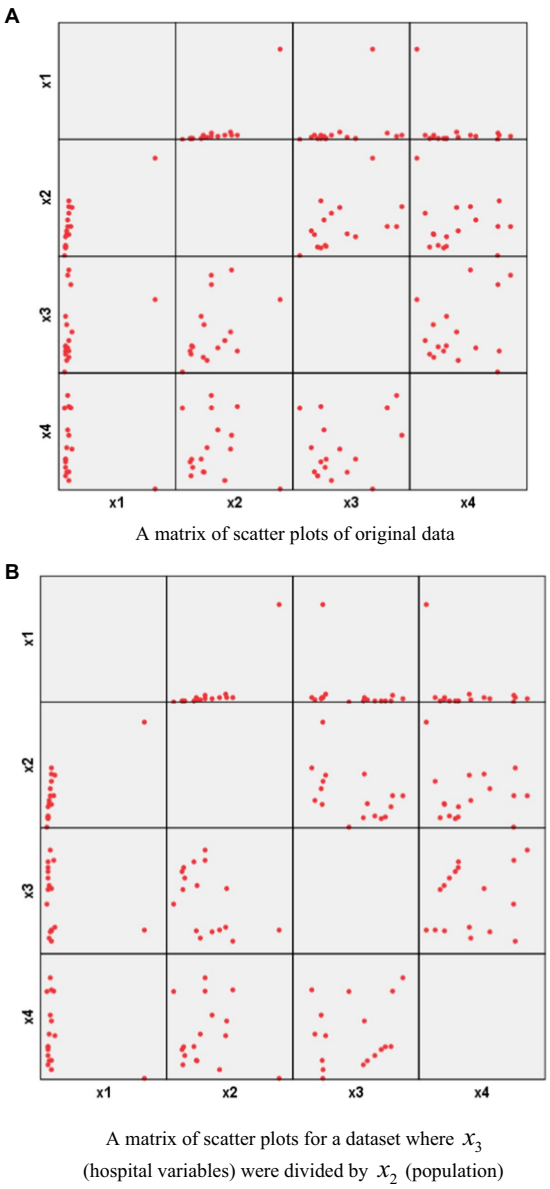

FIGURE A1
(A) A matrix of scatter plots of original data. **(B)** A matrix of scatter plots for a dataset where x_3 (hospital variables) were divided by x_2 (population).

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From kinship networks to culture of relatedness: a shift of safety nets during health pandemics in the kenyan context

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Evidence suggests that, during pandemics such as COVID-19, people with low incomes within developing countries suffered disproportionately. Households across countries differentially experienced the socio-economic impact of the pandemic. In sub-Saharan Africa, the extended family and the community have provided valuable support in crises, given that state-administered backing may not be sufficient or may differ from the family's expectations. Many studies have been conducted on community safety nets, yet little description and understanding of community safety nets has been provided. The components of the non-formal safety nets are yet to be adequately defined or evaluated for effectiveness. Traditional family and community safety nets have been under stress due to the impact of COVID-19. Many countries, including Kenya, have associated COVID-19 with an increased number of households facing social and economic crises. Families and communities got fatigued due to the extended period and the further strain the pandemic had on individuals and societies. Utilizing existing literature on the socio-economic impact of COVID-19 in Kenya and the roles and perceptions of community safety nets, this paper seeks to explain the roles and perceptions of social relationships and kinship networks as safety nets in Africa, specifically in the Kenyan context. This paper employs the concept of culture of relatedness to understand the informal safety nets in Kenya better. During the COVID-19 pandemic, individuals strengthened the previously weakened kinship structures. They addressed some of the challenges experienced within the networks through the involvement of neighbors and friends embracing the culture of relatedness. Therefore, government strategies for social support during pandemics need to design programs to strengthen the community safety nets that remained resilient throughout the health crisis.

KEYWORDS

kinship, community safety nets, coping mechanisms, pandemics, COVID-19

Introduction

A policy brief by the Strategic Policy Advisory Unit (Unit, S.P.A) noted that the COVID-19 pandemic had had direct and indirect effects on the socio-economic levels of households. This policy brief further states that the impact of COVID-19 varies from an income earner in the family falling ill, which leads to a drop in the ratio of active members to dependents to when it is the dependents of the income earner who fall sick (1). The effects of COVID-19 may be intensified by lost avenues for earning a source of livelihood and taking care of the ailing family member or even by funeral expenses incurred upon death (1). A policy brief noted that

ill-health and limited resilience capacities could create multiplier effects (1). The COVID-19 pandemic is a more significant health crisis since its impact has been felt at the core of societies and economies (2). Despite the variations in its effects on countries, COVID-19 will likely increase poverty and inequalities globally, bringing a greater urgency toward achieving Sustainable Development Goals (S.D.G.s).

The Organization for Economic Co-operation and Development (OECD) noted that countries across the globe introduced stringent confinement measures during the pandemic (3). The core aim of the confinement measures was to reduce and contain the spread of the COVID-19 virus. This act of individuals' confinement was also geared toward reducing the unbearable pressure on hospitals and, ultimately, reducing the pandemic's death toll (3). Accompanying the confinement measures, as noted by OECD, were side effects such as a significant supply shock, as workers were forced to stay home and many businesses were temporarily shut down. Another side effect was the reduced demand for many goods and services as households and companies could no longer physically or financially afford them. In this unprecedented situation, countries grappled with minimizing the lockdown's impact on their citizens' livelihoods. Governments discussed how to support the citizens, with all debates anchored on sustainability (1). The fiscal sustainability worries of Governments were put on hold as policymakers geared toward averting more profound socio-economic crises.

In the Kenyan context, the speed and severity of the pandemic shock have been met with unprecedented levels of support, both in-depth and scope (1). Like other health pandemics, COVID-19 increased the short-term shocks and long-duration stresses in Kenya as in other developing countries (4). As Arnall et al. (4) noted, these shocks and stresses result from economic decline, increased poverty, and deteriorating living conditions. The household responses to the pandemic have depended on the household's available assets, the economic context, past migration history, and contemporary rural links. The solutions to the shocks and stresses of COVID-19 have been influenced by disease prevalence and its effect on the household. The kind of support received also depends on the social/ethnic group a family belongs to, with associated kinship patterns (4). Marriage and associations individuals hold within their households and beyond also determine the kind of support individuals receive as a response to the stresses and strains of life resulting from COVID-19. The answers to the shocks and anxieties due to the pandemic depended on the government's capacity to deliver services and activities to non-governmental organizations. Despite all the structures put in place to address the socio-economic stresses resulting from COVID-19, the sustainability aspect of this support still needs to be evaluated.

During the COVID-19 pandemic, the Government of Kenya helped support families through specific initiatives geared toward alleviating or reducing the shocks and stresses of the pandemic (1). The cash value of the grants was, however, relatively small to address the significant impact of the pandemic on households (1). It is important to note further that the social protection offered by the Government of Kenya had previously not been set apart for addressing shocks and stresses that resulted from COVID-19. The Kenyan Government's social protection manages socio-economic needs such as hunger, the old, orphans, and vulnerable communities (1). Therefore, it puts pressure on the kinship networks, both those based on genealogy and eventually involving those not related by genealogy, including friends, neighbors, and community members working together to assist those in need.

Researchers noted that informal community arrangements generally work well under certain circumstances (4). They can, however, begin to break down due to stress and strain due to prolonged or widespread seasons of crisis, as the one experienced due to the long duration of COVID-19 (4). Moser (5) shows how the pressures of economic crisis can exert opposing forces on local transfer relationships, strengthening them through increasing reciprocity networks, and eroding them, as households' ability to cope deteriorates and community trust breaks down. According to Reece (6), families must find ways to reconfigure their relationship, thus incorporating their growth and reproduction through sufficient distance within the kinship structure. During pandemics and times of strain and stress, the question is how families will create space, yet it is a time of need. Given the long duration that COVID-19 has been with us, it is essential to look at the impact of the pandemic stresses on kinship safety nets. The COVID-19 period was when family members needed each other most. Yet, it was a period of immense socio-economic stress and care burden in Kenya—understanding the perception of individuals on the structure and function of kinship networks in the context of COVID-19 in Kenya. This paper, therefore, sets out to utilize existing literature and theories on kinship and safety nets to identify and describe the components of community safety nets and how they have changed over time. It also endeavors to further understand the roles and perceptions of social relationships and kinship networks as safety nets within Africa, specifically focusing on Kenya.

Toward understanding community safety nets during a pandemic

Researchers challenged the safety net discourse with the emergence of social protection in the late 1980s and early 1990s (7). Devereux and Sabates-Wheeler (7) further documented that during the 1990s, thinking on livelihoods, risk, vulnerability, and the multidimensional nature of poverty became more pronounced. Studies increasingly criticized safety nets as residualist and paternalistic, proposing more sophisticated alternatives (7). In low-income countries, social protection continues to be perceived by governments and donors as providing unsustainable transfers to individuals unwilling to work and transform their socio-economic status. Social protection has further been deemed a diversion of scarce public resources from productive investment, which should be used for economic growth (7). On the contrary, it is essential to note that when individuals are empowered and enabled, they can contribute to the economic growth of their societies. The effects of diseases and sicknesses such as COVID-19 can be a great source of strain, impeding individual productivity and contribution toward economic development.

Development agencies have, however, continued to conceptualize social protection mainly as a public response to livelihood shocks (7). This article views social protection with a broader lens away from the perception of resource transfer. It encompasses the dimension of social services provision toward reducing vulnerability and risk of individuals due to the impact of disease and pandemic. According to an International Labor Organization (I.L.O.) report[1] on social protection, state-administered social insurance within sub-Saharan Africa is insufficient. I.L.O.[1] further notes that one of the most pressing challenges for social protection in Africa is access to health care, mainly due to financial constraints. In Kenya and Senegal, the government pays 45 percent of total health expenditure as out-of-pocket payments[1]. The report further mentions that catastrophic health expenditure is one of the significant poverty risks for individuals and their families. Paying for medicine and health care may force families into poverty for years. These challenges prompt further support through kinship ties to enable household members to access economic, social, psychological, and emotional support from relatives, friends, and neighbors in times of need. According to Reece (6), Societies expect families in many contexts to persist indefinitely while accommodating massive socio-political change and great upheavals such as pandemics.

The informal safety nets, including family members, neighbors, friends, and community associations, contribute to household support systems, especially during pandemics such as COVID-19. However, these community safety nets are inadequately described and poorly understood, as noted by Foster (8). The key pillars of the informal social security provision or community safety nets include reciprocity and social cohesion (7). A study conducted in Uganda noted that to guarantee sufficient social protection in good and bad times to all members of any ethnic nationality, the acts of reciprocity, altruism, social cohesion, and personal intimacies were inevitable in ensuring equity and social justice (9). Researchers have nevertheless criticized the view based on often engendering relations of subservience and dependence (10). Mkhwanazi and Manderson (11), in their book "Connected Lives," a study conducted in South Africa, have, however, noted that kinship and residence, families, and households connect and give meaning to lives. They further state that families and households care for basic human needs: food and shelter, reproduction, and social and daily production. The care provided to individuals occurs whether the family is biologically based or chosen, heterosexual or otherwise, large or small, matrilineal or patrilineal, nuclear or extended.

Households might draw their core members from marriage and blood ties or intentionally have members drawn together through love and affective ties. Families can be very small and stable or extremely large and fluid, spreading and shrinking as personal circumstances and domestic and local economics allow (11). They (11) also underscore the importance of families in providing practical and emotional ties for people to feel supported; households give the settings in which these ties are lived out daily. Beyond and within households, families provide the structures and resources for everyday life and the context through which people manage intermittent, often minor but sometimes catastrophic, health, economic, and other crises (12). According to Mkhwanazi and Manderson (11), families are at the heart of birth, death, health, and illness. They (11) further find out that it is within families and households that biology and sociality are intertwined.

Despite the feelings of subserviency and dependence, as shown by Davies (10) in a critique of the acts of reciprocity and altruism that individuals receive during a pandemic and the socio-economic stress accompanying a pandemic, families, households and communities have proven to remain intact to support each other. Kin and family, in this sense, are idealized as sources of intimacy and belonging (6). Reece (6), in the study on pandemic kinship: Families, intervention and social change in Botswana's time of AIDS, notes that the idealized intimacy brings unique risks and danger or influx in the sense of belonging. Therefore, despite the solidarity and deep interdependency within the kinship, tensions emerge given the diverse modes of personhood (6). Given the extended period of the pandemic, there is a need to establish the role and perceptions of kinship support. Its effect on the Kenyan context was such that most of the kin relied on their savings, incomes, and help from friends to meet COVID-19-related expenses such as hospital bills. During the early stages of the pandemic, most health insurance companies did not cover COVID-19 treatment and, worse off, funeral costs in the cases of death of kin within the Kenyan context, impacting heavily on people's lives.

An analysis of the role and perceptions of social relationships and kinship networks as safety nets

Studies have shown that social relationships are linked to better health in several ways; however, this is only in theory and may vary in practice (13). Heady and Grandits (13) further mention that social relationships play several vital roles, including providing emotional benefits such as intimacy, a sense of belonging, and self-esteem. Through physical assistance, such as money, goods, services, and advice, social relationships continue to offer instrumental help (14). Durkheim's (15) studies on the association between social isolation and suicide included reports on the benefits of social networks to health care, for example, how social support and social engagement reduce mortality risks and disability (16–19), improve disease recovery rates (20), and promote cognitive development and function (21, 22). The anthropology of kinship has majorly focused on aspects of solidarity and deep interdependency, as noted by Reece (6). Reece (6) further states that tensions emerge within kinship, given the diverse modes of personhood. Although most studies focus on the beneficial effects of social relationships, networks may also contain relationships that negatively affect mental and physical health (23, 24). This further calls for analyzing social networks within their sociocultural context and their Influence on health and wellbeing.

Barnett (25) defines kinship networks as extended family, including biological relationships, genealogy, marriage, and other self-ascribed associations beyond the nuclear family. Barnett (25) further notes the conceptualization of kinship as socially and culturally constructed and a maintained network of individuals

1 https://www.ilo.org/africa/areas-of-work/social-protection/lang--en/index.htm

in constant flux and not fixed on the genealogical relationship. Therefore, biology, sexuality, and descendancy are no longer the sole defining factors in understanding kinship (25). There have been increasingly blurred boundaries between kinship, community, and friendship networks. Historically, marriage and kinship are the most significant factors that organize and structure people's economic, political, and social lives (25). Marriage, however, was not for the benefit of the husband and wife only, but it played a social function with secondary consideration to women's and children's needs (25). Barnett (25) further notes that marriage and the consequently emerging kinship ties and networks would help raise capital, maintain privilege and family lines across generations, organize the division of labor, create political alliances, and define parent-children authority relationships.

Nevertheless, the family's role has changed over time and space. Changing marriage, cohabitation, divorce patterns, declining fertility, and aging populations affect the family's social security role. Barnett (25) notes that the emerging features of contemporary families are not particularly new. He (25) further asserts that numerous historical records of non-traditional family patterns existed, including; high divorce rates, extramarital sex, out-of-wedlock births, step-families, and rare occasions of culturally accepted same-sex marriages. Studies have mentioned families as the most important social support structures for all human beings worldwide (11). However, the dynamism within the form and role of kinship networks makes it necessary to establish the current range of strategies the kin explores during pandemics such as COVID-19.

Structural analysis of kinship networks maps the relationship between individuals. It examines social ties and the frequency of contacts, directness of interaction, network density, household composition, and generational exchanges, among other variables. Functional analysis of kinship networks focuses on the construction and maintenance of social ties; questions of reciprocity; and the kind and amount of support given and received by members of the network, including instrumental (care work, household help, and financial and material assistance) and expressive (socioemotional and psychological) support (25). Situating kinship and social support network studies within cultural contexts are essential to refine and extend the concept's understanding (26). This helps to refine and extend understanding of the concept (26). Kinship networks usually do not operate on market principles of exchange (most commonly money). Kin status instead comes with clear and well-defined rules of behavior and responsibility, albeit reciprocity holds kinship networks together. Reciprocity refers to members' ability to give back (25). Barnet (25) further notes that reciprocity is often approached from a utilitarian social exchange perspective, providing a challenging and complicated task of assessing value in networks based on affectionate ties and emotional attachment. For this reason, some researchers theorize reciprocity as a norm that brings on culturally determined obligations and governs desirable human relationship patterns (25). Anchors and network members actively construct perceptions and vocabularies of value outside the monetary realm and navigate a structurally determined landscape, evaluating and measuring each other's commitments, needs, intentions, and abilities compared to their own. Mann and Delap (27) noted that in Kenya, family and close friends cared for a regular part of childhood. Further to this study, it would be interesting to know the perceptions of the Kenyan community on the aspects of kinship support networks in the wake of COVID-19.

The Kenyan community is majorly patriarchal. In the patriarchal societies in Kenya, payment of bridewealth provided space and suitable resources for children and their mothers within the kin group (28). The husband was responsible for his wife's conjugal rights, while the entire community was responsible for socializing their children (29). In addition to the socialization process, the community was also responsible for supporting the orphaned children and widows (30). This communal kin assistance has, however, shifted due to socio-economic challenges and changes in the kinship structure and uncertainties during pandemics such as HIV/AIDS over time, forcing widows to seek alternative sources of support (30).

HIV/AIDS as a pandemic prompted the need to review kinship structures and roles during that time. During the COVID-19 pandemic, individuals in Kenya suffered economically, socially, and even psychologically (1). The disease burden and its impact on the few available resources significantly affected the family. For instance, at some point, most COVID-19 patients would not get hospital admission but had to be taken care of from home, yet some of the patients were the breadwinners of their families. Families had to take care of their kin independently within the home setting, which had also been suffering the COVID-19 socio-economic effects. This scenario also concurs with a study conducted in South Africa by Mkhwanazi and Manderson (11), who revealed that affective, social ties have continued to bring meaning to people's lives. They (11) noted that the power of family relations is irreplaceable despite any form of outsourced services, such as when caregivers, for example, nurses, come in to care for the sick. Hence the need to further look at the challenges the kinship networks have faced despite being the major resort of care for the sick and economic support.

The policy brief by the Strategic Policy Advisory Unit (Unit, S.P.A) (1) indicates that family networks, especially during the COVID-19 pandemic, were most often anchored and constructed by women. This brief (1) further noted that women faced the burden of care for extended family members and children when they were not in school during the COVID-19 pandemic. Nonetheless, even in female-anchored networks, men play important roles through instrumental and expressive support. About the Ebola disease, Mulvihill (31) noted that women were responsible for taking care of ill family members, exposing them to a higher risk of contracting the disease other than sacrificing their time too. The confinement measures that Governments introduced to help reduce the spread of COVID-19 entailed more people staying at home, burdening women with more household chores. Kenyan women, for example, account for 50.5% of the population (32) and spend 11.1 h on care work compared to only 2.9 h by men (33).

Oxfam (33) further states that at the pandemic's peak, Kenya's public and private health facilities faced the challenge of accommodating more patients due to the low capacity of the isolation wards. This challenge forced individuals to manage the infected persons at home, a caring process mainly by women. Women tend to be caregivers for the sick in healthcare settings and

at home, which can expose them to more infectious agents than men (33). According to Mkhwanazi and Manderson (11), gender norms continue to dictate women's and men's roles. Furthermore, they (11) concur with the previous reports that society often sees women as the caretakers of the sick and domestic chores. At the same time, society deems to be responsible for income generation. Mkhwanazi and Manderson (11) further mention that there are instances when men take on caregiving when family support systems are thin, as has been the case during the COVID-19 pandemic.

The current context of kinship networks in kenya: a shift to cultures of relatedness

The patriarchal society in Kenya has its kinship mainly based on blood ties. Traditionally, the Kenyan family is tasked with the provision of moral, ethical, spiritual, and cultural content to individuals (34). The family also meets the physical and emotional needs of its members. However, the family structure has experienced some changes due to strains in social relations. For example, during the H.I.V./AIDs pandemic in Kenya, orphaned and vulnerable children were fostered traditionally through kinship care (35). However, family and community support dwindled due to changes in population structures where economically productive populations drastically reduced due to H.I.V./AIDs (36). Fostering of kin is one of Africa's essential practices, including in Kenya. It entails the circulation of children to extended kin networks and communities (34). The kinship structure has often been regarded as a critical agent of care and protection for children (36, 37). However, this structure has weakened, forcing families and kin to opt for institutional care for their family members in crisis, including orphaned and vulnerable children (34).

The concept of the cultures of relatedness (2000) proposed by Janet Carsten examines relatedness as a broader concept of kinship, enlarging the analytical territory. It has opened the door to a general social contextualization of kinship (37). The concept of relatedness brings people to a new consciousness of their connections to others in a comparative context (37). Some of these connections may be valuable socially, materially, or affectively. Carsten (37) further notes that relationships may not always be decided on genealogy but can also be described in other ways. For example, among the Nuer people of Southern Sudan, there have been connections and disconnections of relatedness due to the profound social and political upheavals that they have faced through time. The Nuer relatedness has come to be understood by researchers through blood and cattle and the media of money, guns, and paper (37). It is necessary to understand how the phrases of relatedness are considered other than having the classic understanding of kinship (37). Studies have viewed the concept of relatedness as a dynamic process involving more than biological relations but more of the daily acts of taking care of each other, even in times of crisis, provoking a re-examination of what constitutes relations.

In the book Chapter Choosing kin: Sharing and subsistence in a Greenlandic hunting community, Nuttal argues that kinship is the foundation of social relatedness and social organization (38). Nuttal, in the book chapter, further notes that kinship is the fundamental organizing principle for subsistence activities in Kangersuasiaqa, a village in North West Greenland (38). Kinship is flexible and can be created by individuals and deactivated when individuals deem certain relationships unsatisfactory (39). During the socio-economic strain due to the COVID-19 pandemic, individuals forged relationships outside the kin to further strengthen the kin relationships by bringing stability in crises. All these acts that further the concept of kinship into cultures of relatedness need to be understood within specific ethnographic contexts. The idea of cultures of relatedness helps to view social support offered to the individuals not just by the kinship members from a genealogical perspective but also from other perspectives, such as support provided by friends and neighbors. Reece (6) notes that crises create, recalibrate, and produce kin relations. Howell (40) examines how individuals may address infertility problems through new reproductive technology (N.R.T.) or adoption. The process of adoption, as noted by Howell (40), assigns nakedness both literally and socially to the child. Howell (40) uses the term of the adopted child having been "de-kinned"-removed from "kinned" sociality, but eventually, through the new family, the children are "kinned." This further shows how social relations are forged further and not only in times of crisis.

Summary of findings

The kinship networks have always been helpful during pandemics such as COVID-19. The confinement measures and the hard-economic times resulting from the loss of income for most of the population meant that the family had to come in and support their kin. Though not well-described, families and kin structures could care for the sick at home when their fellow kin could not afford hospital care. Kinship structures supported family members to sustain their livelihoods by contributing to buying necessities for each other. Kin relations, neighborhood, and community structures were further strengthened and provided support and care for its members despite the negative impact of the pandemic. However, the long duration of the COVID-19 pandemic caused emotional, social, physical, and financial fatigue in families forcing individuals to forge new relations outside the family and the kin structure. Individuals reach out to friends and neighbors who are not related to them by blood but through social relations to get social support, given the insufficiency of the government's social support. Therefore, the shift occurred from kinship networks to cultures of relatedness and eventually social relatedness toward supporting each other during the COVID-19 pandemic.

Conclusion

As a result of COVID-19, its long duration had significant social and economic stresses and strain in the Kenyan context. The Government alone could, however, not addresses these challenges. The kinship networks comprising family and close family friends helped to relieve individuals of the socio-economic challenges caused by COVID-19. There is a saying in Kenya that kinship relationships due to marriage are always complimented through

friendship. There is a need to contextualize the various social support networks provided by family and kin relationships. During the pandemic, the support networks extended to neighbors and all social networks created by individuals apart from their families. The aspect of context is vital, given the dynamism experienced within the family and kinship system today. The changes in family and kin relations structure, coupled with the long duration of the pandemic, affected the levels of support. Therefore, further studies can be conducted within different contexts, especially where there have been drastic changes in the family structure and how these changes have affected social support during a pandemic.

Limitations of the study

This paper can indeed help advise policy on social protection systems in Kenya. However, it is limited in its methodological approach, given that the current study did not engage in fieldwork to describe the kinship structure, its roles, and kin perception. However, given the socio-economic challenges families experienced during the pandemic, it was necessary to note that the kin structures were strengthened and further expanded outside the biological kin.

Recommendations

1. It would be interesting for researchers to conduct a field study exploring the change of structures within the kinship networks in the wake of COVID-19 within the Kenyan context, given that kinship is socio-culturally constructed and maintained rather than based on genealogy.
2. There is a need to examine the structural dynamics within kinship networks significantly and how they have impacted the provision of safety nets among the different members of society.
3. The disruption and weakening of the non-formal intergenerational transfers have had a different picture during the COVID-19 pandemic. Kin relations, neighborliness, and community structures were strengthened further during COVID-19. This was evident through providing support and care for family members independently despite the pandemic's negative impact on individuals' lives. Therefore, in designing social protection programs to mitigate the socio-economic consequences of pandemics such as COVID-19, policymakers need to create programs that consider building socio-economic resources of households and strengthening community safety nets.
4. During a crisis, Governments help individuals through monetary transfers, material support, and services other community members offer (41). These kinds of assistance are not viable during pandemics such as the COVID-19 pandemic. Kin relations have therefore continued to help families recover and become self-sufficient in crises. The Government of Kenya needs to acknowledge and integrate the various roles played by the kinship networks as they provide valuable support even to the extent that the Government may not reach toward ensuring healthy lives and promoting wellbeing for all at every age.

Author contributions

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Conflict of interest

The author declares that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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To PCR or not? The impact of shifting policy from PCR to rapid antigen tests to diagnose COVID-19 during the omicron epidemic: a nationwide surveillance study

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Background: Coronavirus disease 2019 (COVID-19) had caused huge impacts worldwide. Polymerase chain reaction (PCR) is the mainstay diagnostic modality. In most hospitals in Taiwan, samples for PCR are collected at emergency department (ER) or outdoor clinics to avoid virus spread inside hospitals. Home rapid antigen test (RAT) is a feasible, low-cost, and convenient tool with moderate sensitivity and high specificity, which can be performed at home to reduce hospital visits. Due to comparably low severity of omicron variant and high vaccine coverage (~80% residents fully vaccinated with AstraZeneca, Moderna, or Pfizer BioNTech COVID-19 vaccines as of March 2022), the policy was shifted from containment to co-existing with COVID-19 in Taiwan. Virus spread rapidly in the community after the ease of social restrictive measurements. To acquire a confirmed diagnosis, PCR testing was requested for people with suspected COVID-19 infection. As a consequence, people with respiratory symptoms or contact history surged into hospitals for PCR testing, thus, the medical capacity was challenged. The diagnostic policy was altered from PCR to RAT, but the impact of diagnostic policy change remains unclear.

Objectives: We conducted this study to investigate the number of COVID-19 cases, PCR testing, hospitalizations, mortalities, and hospital visits during the epidemic and evaluate the impact of diagnostic policy change on hospital visits.

Methods: The diagnostic policy change was implemented in late May 2022. We used nationwide and hospital-based data of COVID-19 cases, PCR testing, hospitalizations, mortalities, and hospital visits before and after policy change as of 31 Jul 2022.

Results: During the omicron epidemic, significant and synchronous increase of COVID-19 patients, PCR testing, hospital visits were observed. COVID-19 cases increased exponentially since April 2022 and the COVID-19 patients peaked in June (1,943, 55,571, and 61,511 average daily new cases in April, May, and June, respectively). The PCR testing peaked in May (85,788 daily tests) with high positive rate (81%). The policy of RAT as confirmatory diagnosis was implemented on 26 May 2022 and a substantial decline of PCR testing numbers occurred (85,788 and 83,113 daily tests in May and June). People hospitalized for COVID-19 peaked in June (821.8 patients per day) and decreased in July (549.5 patients). The mortality cases also peaked in June (147 cases/day). This trend was also validated by the hospital-based data with a significant decrease of emergency department visits (11,397 visits in May while 8,126 visits in June) and PCR testing (21,314 in May and 6,158 in June). The proportion of people purely for PCR testing also decreased (10–26 vs. 5–14%, before and after policy change, respectively).

Conclusions: The impact of diagnostic policy change was a complicated issue and our study demonstrated the huge impact of diagnostic policy on health seeking behavior. The PCR testing numbers and emergency department visits had substantial decrease after diagnostic policy change, and the plateau of epidemic peak eased gradually in ∼1 month later. Widespread RAT application may contribute to the decreased hospital visits and preserve medical capacity. Our study provides some evidences for policy maker's reference.

KEYWORDS

COVID-19, omicron, polymerase chain reaction, rapid antigen test, SARS-CoV-2, policy

1. Introduction

The long-running battle against the coronavirus disease 2019 (COVID-19) pandemic has entered the 3rd year, while human life has been substantially affected in all aspects (1, 2). The virus continues to evolve, and among the variants, the omicron variant is highly contagious and less severe (3, 4). Furthermore, vaccines against severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) have become widely available, and vaccinated individuals have a significantly lower risk of severe complications from COVID-19 (5, 6). Although the efficacy of the COVID-19 vaccines is less effective for omicron variant, vaccination remains effective to reduce severe complications after infection (7). Antiviral agents are beneficial for older adults, immunocompromised hosts, and other high-risk groups, meanwhile, timely diagnosis to allow early treatment is crucial to improve clinical outcomes (8, 9). Therefore, reconsidering the policy of a stringent control strategy to contain and control the pandemic is emerging in many countries (10). In 2022, the policy of coexisting with COVID-19 was adopted in Taiwan, and easing of containment strategies was implemented step by step (10, 11). The gold standard of COVID-19 diagnosis is polymerase chain reaction (PCR) which is widely adopted in Taiwan. To ensure the quality of PCR sampling, reduce nosocomial viral spread, and prevent transmission to susceptible and high risk patients inside hospitals, PCR sampling was performed at emergency departments (ER) or outdoor clinics in most Taiwan hospitals (12, 13). Walk-in clinics and drive-through testing stations are not widely available in Taiwan. This PCR-based strategy can decrease false-positive and negative rates of RAT, but people may surge into hospitals to receive PCR testing and thus cause collateral damage to people without COVID-19. The home rapid antigen test for SARS-CoV-2 (RAT) is a convenient tool with moderate sensitivity and high specificity when comparing with PCR (14, 15) and can be performed at home. To ensure early detection of infection cases and initiation of appropriate infectious control measures, RATs were not used in the initial phases of pandemic in Taiwan. During the process of reopening and coexistence, the number of COVID-19 cases increased exponentially, and medical capacity was challenged. The medical system may collapse during an epidemic surge (16–18). Therefore, the application of RATs to replace PCR as confirmatory tests was considered to decrease unnecessary hospital visits. In late May, the policy to diagnose COVID-19 changed from PCR testing to RATs. However, the impacts of shifting the diagnostic policy on health-seeking behaviors remain largely unclear.

By March 2022, ∼80% of residents in Taiwan had been fully vaccinated (11). There has been an omicron epidemic in Taiwan since April 2022. There were 0.88 new cases daily per million residents on 01 Jan 2022 and 5,404.63 new cases on 14 May 2022 (2, 10). Although the majority of COVID-19 cases are mild and do not require hospitalization (4, 19), a rapid increase in cases is associated with a rapid increase numbers in hospitalizations and mortalities, especially for high-risk people (4, 20, 21). Furthermore, PCR testing played important roles in many scenarios at that time, including diagnosis confirmation, prescription of antiviral agents, admission routine tests, and proof for insurance payments. Confirmation of COVID-19 by PCR testing was required at that time to establish the diagnosis and prescribe antiviral medication in

a timely manner. All hospitalized patients were requested to receive PCR testing before admission to reduce nosocomial transmission of SARS-CoV-2. Moreover, proof of PCR testing was necessary for quarantine, pandemic leave, and insurance payments. People with confirmed infection had to be quarantined for 7 days to reduce disease spread in the community and a proof by PCR testing was needed for schools and companies. Additionally, several companies unveiled an insurance policy with an NTD$500 (∼17 USD) payment and NTD$50,000 payout if the individual had to quarantine. Therefore, during the omicron epidemic, people with fever, respiratory symptoms, or a history of contact with COVID-19 patients surged into the emergency department to asked for PCR testing. As a result, the rapid increase in the number of patients became a big challenge for the medical system, and thus resulted in the impending collapse of medical services, especially in emergency departments. Shifting diagnostic policy from PCR to RATs may decrease the need for emergency visits and preserve medical capacity. We conducted this retrospective study using nationwide and hospital data of COVID-19 patients, including diagnostic testing, hospitalizations, mortalities, and hospital visits. We investigated the epidemiological trends before and after the policy change to evaluate the impacts of the diagnostic policy change from PCR testing to RATs.

2. Materials and methods

2.1. Study design and data collection

COVID-19 is a communicable disease, and all confirmed cases will be reported to Taiwan Centers for Disease Control and Prevention per the domestic regulation. We retrospectively collected epidemiological data from public data sources and our hospital-based visits (2, 10). First, we extracted epidemiological information regarding the daily new COVID-19 cases, the COVID-19 vaccination rate, daily new tests, the PCR positive rate, and the mortality cases from the open access website OurWorldInData.org (2). The definition of new case evolved by time. New cases were diagnosed by PCR before late May 2022 and then diagnosed by both PCR and RAT afterwards. The PCR results were reported to the government by medical care units; after diagnostic policy change, the positive RAT results could be reported to the government via telemedicine or by medical care units. The mortality cases referred to deaths of patients with positive tests without obvious alternate causes. Fully vaccinated people refer to people with two doses of COVID-19 vaccines or one dose of Johnson & Johnson/Janssen vaccine. In Taiwan, there were several kinds of COVID-19 vaccines available in different periods, including AZD1222 (by AstraZeneca/Oxford, UK), mRNA-1273 (by Moderna, USA), BNT162b2 (by Pfizer/BioNTech, Germany), Nuvaxovid (by Novavax, USA), and MVC-COV1901 (by Medigen, Taiwan). COVID-19 vaccines were freely provided to residents and full vaccination indicated two doses of homologous or heterologous administration of above vaccines. A booster referred to a third dose of mRNA vaccine (mRNA-1273 or BNT162b2) or protein-based vaccine (Nuvaxovid or MVC-COV1901). The national hospitalizations were extracted from the website of Taiwan Centers for Disease Control (10). The 7-day average was summarized to decrease the artificial peaks or valleys observed on weekends. Second, we extracted the number of emergency department visits to our hospital since 2019 to validate the nationwide trend and investigated the impact of the omicron epidemic on patient visits. Finally, we compared the trend in PCR tests and emergency visits before and after the diagnostic policy change to evaluate the impacts of the policy change.

2.2. Ethical considerations

The present study was approved by the Institutional Review Board of the MacKay Memorial Hospital, Taipei, Taiwan (approval number 20MMHIS140e). We utilized database analysis, and no personal identifiable information was used in this study.

2.3. Statistical analyses

We plotted the trends for new COVID-19 cases, PCR tests, and patient visits using Microsoft Office, version 2019 (Microsoft Corp, New Mexico, USA). Linear regression analyses were performed using the equation of linear trend estimation. The slope of the regression line indicated a positive or negative change in trends. R^2-values were also calculated, and a higher R^2-value indicated lower discrepancies between datasets. Furthermore, we used independent t-tests to compare the monthly patient visits in the pre-epidemic and epidemic periods and the number of PCR tests before and after the policy change. An interrupted time series analysis was performed to evaluate the impact of the policy change intervention (22). A p-value < 0.05 indicated statistical significance. SPSS version 23.0 (IBM Corp, Armonk, NY, USA) and R software version 4.2.1 (R Foundation for Statistical Computing, Vienna, Austria) were used for statistical analyses.

3. Results

3.1. Epidemiology of COVID-19 patients and ER visits

Figure 1 summarizes the epidemiological trend in 2022. As of 31 July 2022, there were 458,185 confirmed cases of COVID-19 in Taiwan (192,297 cases per million residents), and ∼80% of residents were fully vaccinated, with 22% boosted. The booster coverage increased to ∼65% by week 23. Both the confirmed new cases and the number of PCR tests increased exponentially after week 16 (April) and peaked by week 20. The number of daily PCR tests decreased after the policy change, and the peak of new cases persisted for ∼1 month. The positive rate of PCR testing increased by more than 80% after week 20.

The numbers of COVID-19 cases, PCR tests, hospitalizations, mortalities, hospital ER visits, and hospital PCR tests are summarized in Table 1. The surge in omicron infection cases began in April and peaked in June (1,943, 55,571, and 61,511 daily new cases in April, May, and June, respectively, Table 1). The plateau of the epidemic declined ∼1 month later (28,101 daily new cases in July). The total number of national PCR tests also increased,

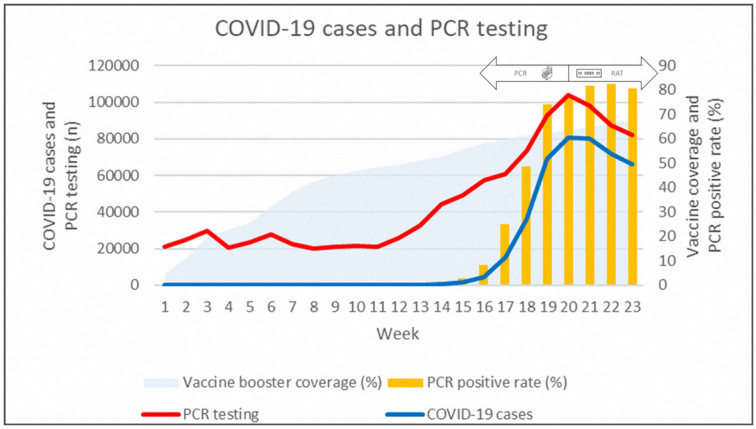

FIGURE 1
Epidemiological data of daily new COVID-19 cases, PCR testing, PCR positive rate, and vaccination booster coverage rate in 2022.

with a peak in late May (85,788 daily tests). The number of COVID-19 hospitalizations and mortalities also peaked in June (822 hospitalizations daily for COVID-19 and 147 mortalities daily). The number of ER visits to our hospital fluctuated, with a small peak from October 2020 to March 2021 and October 2020. A significant increase was observed in May 2022. Compared with the same month, a more than half increase in monthly visits was observed in May 2022 (2020: 5,333, 2021: 6,471, 2022: 11,397 visits). ER visits decreased in June 2022 (11,397 visits). The proportion of visits purely for PCR testing also decreased (26, 10, and 5% in April, May, and June, respectively).

Figure 2 demonstrates the epidemiological trends in COVID-19 cases, PCR testing, hospitalizations, and mortalities. The peak of PCR tests was week 20, and the peaks of daily new cases, hospitalization, and mortalities followed.

Figure 3 shows the monthly ER visits at our hospital. After the beginning of the pandemic in 2020, ER visits declined substantially. A small peak was observed after the end of the pandemic between October 2020 and March 2021. The number of ER visits increased rapidly after April 2022 and declined after the policy change in late May. The proportion of ER visits purely for PCR testing also declined after the policy change.

3.2. Impact of the policy change on testing

Table 2 summarizes the trends in new COVID-19 patients, nationwide PCR testing, hospitalizations, mortalities, and hospital-based PCR testing. Negative trends were observed after the implementation of diagnostic policy changes, especially for new COVID-19 cases and hospitalizations. Furthermore, interrupted time series analysis showed a significant difference after the intervention (Figure 4). The black circles indicate the number of national daily PCR tests, with the peak in May. The blue lines demonstrate the independent trends before and after implementation of the policy change, and a significant reverse trend was observed. The red line indicates the same trend (slope) throughout the whole study period, and the step change indicates the impact of the policy change as a single episode. A substantial reduction in PCR testing was observed as a step change after implementation of the policy change.

4. Discussion

Our study demonstrated exponential increases in the numbers of COVID-19 cases, hospitalizations, and mortalities during the omicron epidemic. PCR testing was the mainstay diagnostic modality and sharp increase of PCR testing coincided with the increase in COVID-19 cases. The number of PCR tests peaked in May, and the numbers of COVID-19 cases, hospitalizations, and mortalities peaked in June. The diagnostic policy change from PCR to RATs may have contributed to the reduction in PCR testing and unnecessary hospital visits and preservation of medical capacity. Our findings provide evidence that can be used as a reference for policy-makers.

COVID-19 continues to be an important threat in many countries, and the complicated multidirectional interactions between COVID-19 infection, the medical system, health policy, and human behaviors remain largely unclear (19, 23). Although many people avoided unnecessary hospital visits to decrease the risk of infection (for example, a significant reduction in childhood vaccinations was reported in many countries) (24), the rapid increase in COVID-19 patients may have resulted in the collapse of public health and medical systems (16, 17, 20, 21). Lockdown strategies, a shortage of human resources for illness or quarantine, and a lack of medication and facilities will aggravate the disruption of medical services (25). Although the prevalence of many respiratory infection decreased during the pandemic, we observed small peaks from October 2020 to March 2021 and October 2020. Outbreaks of respiratory syncytial virus may contributed to the observed peaks (26). During the omicron epidemic, our study showed synchronous increases in COVID-19 cases, hospitalizations, and mortalities, and we also found a significant increase in ER visits. After the diagnostic policy was changed from PCR testing to RATs, a significant decrease in ER

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TABLE 1 Average daily numbers of national COVID-19 patients, PCR testing, hospitalizations, mortalities, monthly hospital PCR testing, outpatient clinic visits, and emergency department visits.

	Year	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
COVID-19 patients (cases/day)													
	2020	1.04	0.88	8	4.95	0.41	0.18	0.54	0.78	0.8	1.3	2.94	4.85
	2021	3.47	1.81	2.32	3.01	195.04	248.47	32.56	11.12	7.71	6.3	6.06	12.17
	2022	53.7	60.06	83.61	1,942.67	55,570.67	61,510.75	28,100.91	22,622.18				
National PCR testing (tests/day)													
	2020	66	301	669	1052	326	154	154	188	208	262	272	501
	2021	862	787	465	579	8,711	27,466	22,924	20,767	23,198	19,241	16,326	15,765
	2022	23,111	22,939	21,747	45,884	85,788	83,113*						
National COVID-19 hospitalizations (7-day average, *n*/day)													
	2022	287.4	221.3	200.1	436.7	747.1	821.8	549.5					
National COVID-19 mortality cases (*n*/day)													
	2022	0.03	0.06	0.01	0.2	34.1	147.1	79.1	33.9				
Hospital monthly PCR testing (tests/month)													
	2020			993	1,772	299	128	209	412	300	654	558	570
	2021	963	1,684	1,062	946	2,695	5,672	5,648	4,899	5,035	5,257	4,494	3,506
	2022	7,340	6,558	7,840	13,209	21,314	6,158	5,468	5,958				
Hospital monthly OPD visits (patient visits/month)													
	2020	54,103	53,424	53,553	49,848	58,826	62,899	67,391	64,548	66,669	67,396	65,310	68,340
	2021	59,951	46,717	69,450	65,368	52,972	43,804	57,423	60,541	60,957	65,100	66,145	66,666
	2022	64,159	50,490	76,842	60,765	55,049	58,063	62,799	67,254				
Hospital monthly ER visits (patient visits/month)													
	2020	8,774	5,694	5,043	4,987	5,333	5,795	6,071	6,552	6,431	8,042	7,813	6,982
	2021	7,049	6,923	7,152	6,728	6,471	5,715	5,720	6,167	6,602	7,343	6,847	6,034
	2022	7,480	6,744	7,778	7,520	11,397	8,126	7,503	7,945				
2022 purely for PCR (%)		1,626 (22%)	1,679 (25%)	1,570 (20%)	1,985 (26%)	1,114 (10%)	406 (5%)	1,023 (14%)	1,141 (14%)				

*As of 22 Jun 2022.

COVID-19, coronavirus disease 2019; ER, emergency department; OPD, outpatient clinic department; PCR, polymerase chain reaction.

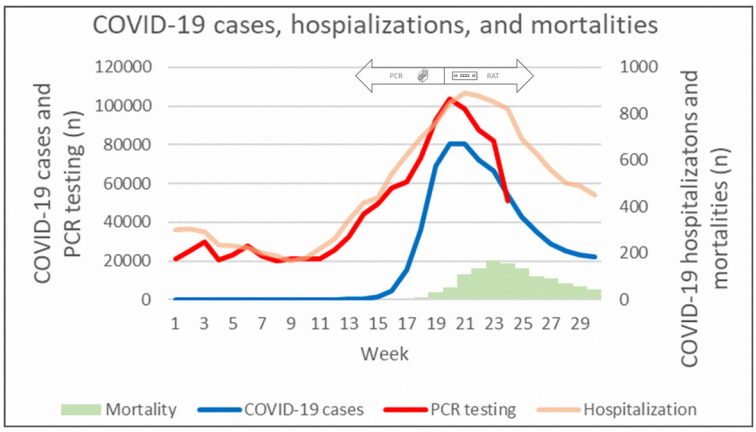

FIGURE 2
Epidemiological data of daily new COVID-19 cases, PCR testing, hospitalizations, and mortalities.

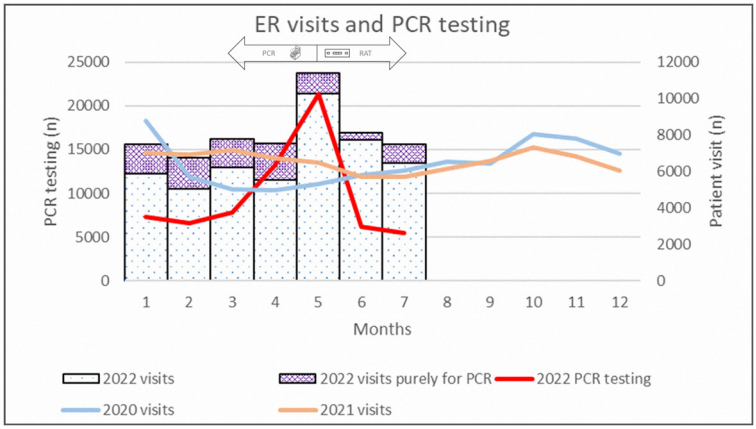

FIGURE 3
Epidemiological data of emergency department visits between 2020 and 2022 and PCR testing in 2022.

TABLE 2 Linear trend in daily national COVID-19 cases, PCR testing and hospital PCR testing before and after the policy change.

	Before policy change (01 Apr 2022–26 May 2022)			After policy change (27 May 2022–31 July 2022)		
	Average	Slope	R^2	Average	Slope	R^2
National COVID-19 cases (daily *n*/million)	24,528	69.8	0.8	47,338	−44.8	0.96
National PCR testing (daily *n*/thousand)*	2,640	0.06	0.95	3,623	−0.05	0.97
National COVID-19 mortalities (*n*)	10.66	0.848	0.64	111.1	−1.369	0.47
National COVID-19 hospitalizations (*n*)	580.2	10.43	0.98	699.7	−8.213	0.94
PCR positive rates (%)*	28.4%	0.018	0.86	81%	−0.0013	0.39
Hospital PCR testing (*n*)	587.2	6.88	0.04	201	−1.64	0.17

COVID-19, coronavirus disease 2019; PCR, polymerase chain reaction. The ∗ indicated the data of PCR testing after policy change was calculated as of 22 Jun 2022.

visits and PCR testing was observed, emphasizing the importance of diagnostic policy in health-seeking behaviors.

During the initial waves of COVID-19, Taiwan adopted "containment" strategies to reduce virus spread and disease burden, and several aggressive and stringent strategies were employed, including border control, proactive testing, and quarantine (10, 12, 13, 27, 28). Based on the increased transmissibility and lower severity of the omicron variant, many countries adopted a "coexisting" policy in 2022, including Taiwan. The omicron variant is highly contagious, and the number of COVID-19 cases increased exponentially (4, 29). Infected people surged into hospitals, and the capacity of medical services was challenged. Fortunately, most people with omicron infection were less severely ill and did not need hospitalization. High coverage of COVID-19 vaccination also reduced the impact of patient surge after ease of social restrictive measurements (30). However, crowds of patients may lead to the collapse of medical services, especially in emergency departments. People had to wait for more than 2 h to undergo PCR testing, and it was difficult to maintain safe distancing in the ER. The risk of catching the infection at the ER and the ostracization of other medical needs should be considered. The road to peaceful coexistence in the omicron era could be painful, and efforts have been made to reduce collateral injuries (4). During the epidemic waves, coincident increases in cases and hospitalizations were reported in previous studies, and mortalities peaked in ∼1 month (4, 6, 19, 21, 31). Hospitalizations and mortalities were complicated and might reach a peak after 1 month of infection peak. Our study showed similar trends, and all new cases, hospitalizations, and mortalities reached their peak in June. Diagnostic policy change didn't change the epidemiological trends, including peaks of new case, hospitalizations, and mortalities. Studies comparing PCR testing are scarce, and it is intuitive that the consumption of PCR tests coincided with the epidemic wave. We found a significant reduction in PCR testing after the policy change, and the epidemic waves declined after 1 month. Although the observed interval between PCR testing and epidemic wave peaks were not long that the clear relationship between diagnostic policy change and health seeking behaviors was not easily identified. Early implementation of policy change may have a more significant and clear impact on the epidemic. Political, environmental, economic, and medical factors may affect medical-seeking behaviors, and our study demonstrated the potentially important role of diagnostic policy during the epidemic. Policy-makers should incorporate public responses into their decision-making process.

Medical insurance has played important roles in the COVID-19 pandemic, but the government and private insurance systems vary in different countries (32–34). During the COVID-19 epidemic, people have typically avoided unnecessary hospital

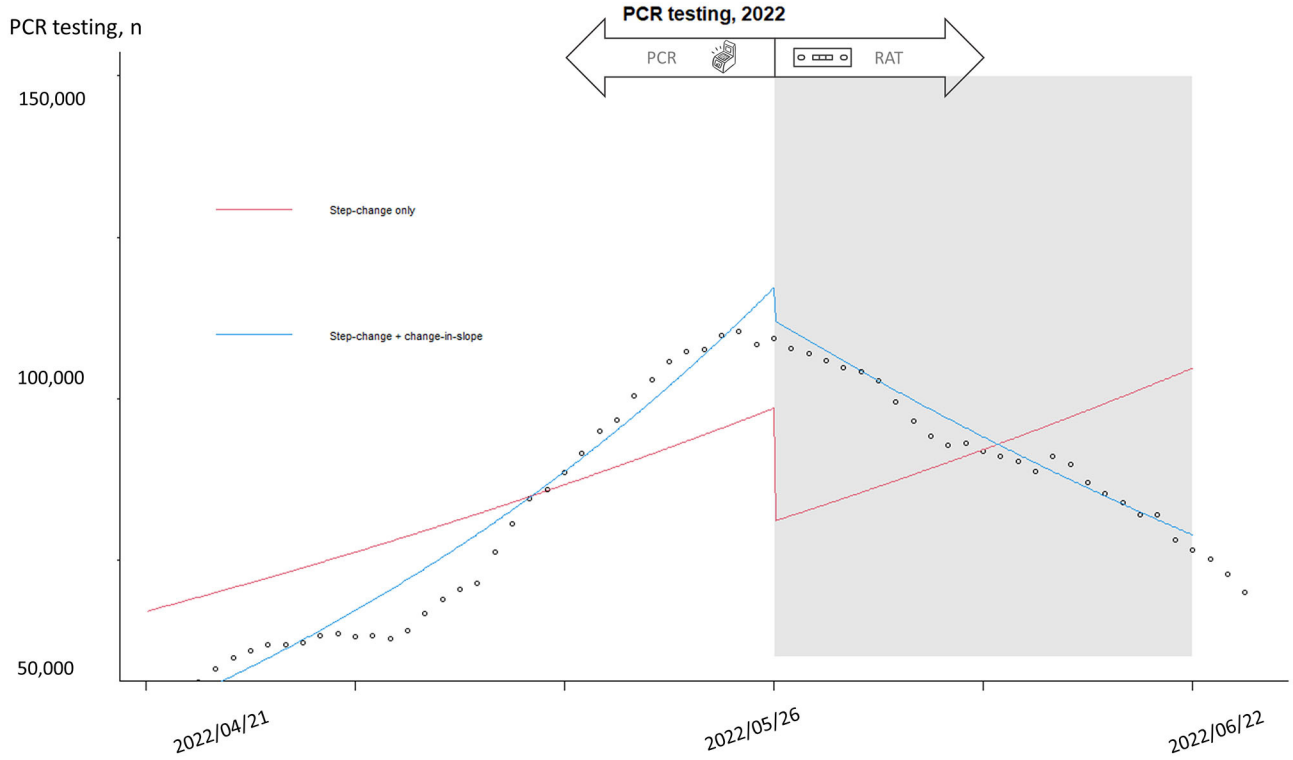

FIGURE 4
Interrupted time series analysis of national PCR testing before and after policy change. Interrupted time series was used to predict the trend with and without intervention. "Step-change only" (red line) refers to the impact of intervention made difference at one time point and a significant reduction of PCR testing occurred after policy change. "Step-change and slope change" (blue line) refers to a continuous impact after intervention and a steady decrease of PCR testing was observed after policy change.

visits to decrease the risk of infection. COVID-19 has had huge impacts on medical services and immunization to different degrees (24). However, medical-seeking behaviors are complicated and affected by many psychological, economic, environmental, and social factors. For example, medical service and vaccination interruptions were reported in many areas during the pandemic and both government-funded and self-paid vaccinations decreased in Taiwan. However, there was an delta epidemic in Taiwan in 2021 and there was inadequate COVID-19 vaccine supply. Under the circumferences, people believed the potentially collateral benefits of pneumococcal vaccination that pneumococcal vaccination contributed to prevent COVID-19 infection and subsequent pneumonia. As a consequence, a reverse increase in self-paid pneumococcal vaccinations was observed (24). During the omicron epidemic, an increase in ER visits was expected due to rapid spread of the virus, but hospital visits may also be affected by non-medical factors. Most patients had mild illness, and ER visits were not needed. Some patients with mild illness visited the ER for PCR testing, and our study showed a significant decline in ER visits after the policy change. COVID-19 is a communicable disease, and a confirmative diagnosis by PCR was required before 26 May 2022. PCR testing was essential for quarantine, office leave, school leave, and insurance payments. Therefore, people with contact history, fever, or respiratory symptoms surged into the ER for PCR testing. Moreover, socioeconomic disparities and a lack of health insurance are important public health issues in COVID-19 (35–37). People with a lower socioeconomic status or no health insurance might have poorer outcomes after infection (38). However, the impacts of COVID-19 on insurers may be conflicting. Life insurers had higher liability during the pandemic and negative impacts on life insurers' financial sustainability may occur for higher mortality rates than expected (39). On the other hand, unexpected health insurance profits were noted due to sharp declines in elective care (40). The special pandemic insurance in Taiwan unveiled an insurance policy with an NTD$500 (~17 USD) payment and NTD$50,000 payout if the individual had to quarantine. This policy earned huge profits for insurance companies in 2021 due to a low prevalence of COVID-19 infection. During the omicron epidemic in 2022, many people were infected, and the insurance company lost much money. The collateral injury of increased ER visits caught our attention, and our study showed a substantial impact of policy changes on PCR testing and ER visits. Policy-makers may take the potential effects into consideration.

Virus culture is time-consuming, and PCR testing is the gold standard for many viruses. Compared with PCR, the RAT is quick, feasible, cheap, and convenient, with moderate sensitivity and high specificity (14, 15, 41–43). For symptomatic patients, the sensitivity of the RAT is ~80%, with a high specificity of 98.9% (43). The estimated positive predicted value (PPV) is 94.1%, and the negative predicted value (NPV) is 95.9%. For asymptomatic people, the sensitivity decreases to 41.2%, and the specificity remains high (98.4%), with a lower PPV of 33.3% and a higher NPV of

98.8%. The performance of the RAT is also affected by sampling methods, kit brands, and diagnostic methods, among other factors (42). In early stages, stringent containment was used and Taiwan government didn't adopt RAT as confirmatory tests for the issues of false positivity and relatively compromised sensitivity. People surged into hospitals and had to wait for hours for PCR testing to be performed. Medical capacity was challenged, and medical collapse may occur during the omicron epidemic. Furthermore, the background prevalence also interferes with the diagnostic accuracy (44). During the overwhelming epidemic stage, the sensitivity of the RAT increased, and using the RAT as a first-line diagnostic tool became a reasonable strategy. We found a high PCR positive rate of more than 80% after week 20, and the need for PCR testing was questioned. This policy can decrease the consumption of PCR testing and provide a timely diagnosis and further quarantine. Physicians can still perform PCR testing for selected cases, such as patients with severe infection. Furthermore, rapid walk-in clinics or drive-through testing stations were adopted in some countries with good efficacy (45). According to our hospital-based data, up to 26% of ER visits were purely for PCR testing. The application of rapid drive-through testing services may provide further benefits for these individuals. Our study provided evidence that diagnostic policy changes can reduce PCR testing and hospital visits. Thus, medical capacity can be preserved for patients with moderate or severe infection.

The strength of our study is that it is the first study to investigate the impact of diagnostic policy change on PCR testing and ER visits in Taiwan. However, our study was subject to some limitations. First, many factors affect health-seeking behaviors, including perceived risks, feasibility of medical resources, family support resources, vaccination status, and feasibility and supply of RATs. We observed a peak gap between PCR testing and COVID-19 cases, but earlier implementation of policy change may present a more significant impact. The degree of the policy change impact is not easily justified. Second, the causal relationship and underlying mechanisms were not clarified. We observed an association between the decrease in PCR testing and ER visits and the policy change, but the roles of the insurance system and socioeconomic factors were not fully elucidated. We are unable to draw a direct conclusion. Finally, our study was conducted in a local hospital. Although national epidemiological data were used, nationwide surveillance data on patient visits would be valuable.

5. Conclusions

In conclusion, the omicron epidemic caused an exponential increase in cases and challenged the medical system in Taiwan in April and May 2022. We observed a significant reduction in PCR testing and ER visits after the diagnostic policy change from PCR testing to RATs. Declines in COVID-19 cases, hospitalizations, and mortalities occurred within ∼1 month. The policy change may have had a huge impact on health-seeking behaviors and medical resources. Our study provides evidence that can be used as a reference for policy-makers.

Data availability statement

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

Author contributions

HC, N-CC, and C-YL: conceptualization. HC, C-CC, W-TL, and C-YL: formal analysis. HC, N-CC, C-CC, and S-LW: investigation. C-HsL and LY-ML: methodology. C-YL: writing-original draft. All authors: data curation, validation, contributed to and reviewed the final submitted manuscript, had full access to all the data in the study, and had final responsibility for the decision to submit for publication.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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The intersectionality-based policy analysis framework: demonstrating utility through application to the pre-vaccine U.S. COVID-19 policy response

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Few guidelines exist for the development of socially responsible health policy, and frameworks that balance considerations of data, strategy, and equity are limited. The Intersectionality-Based Policy Analysis (IBPA) framework utilizes a structured questioning process to consider problems and policies, while applying guiding principles of equity, social justice, power, intersectionality, and diversity of knowledge and input. We apply the IBPA framework's guiding principles and questions to the pre-vaccine U.S. COVID-19 policy response. Results suggest the IBPA approach is a promising tool for integrating equity considerations in the development of policy solutions to urgent US public health challenges, including the COVID-19 pandemic. We found the IBPA framework particularly useful in differentiating between problems or policies and representations of problems or policies, and in considering the impacts of representations on different groups. The explicit inclusion of short-, medium- and long-term solutions is a reminder of the importance of holding a long-term vision of the equitable public health system we want while working towards immediate change.

KEYWORDS

intersectionality, public health policy analysis, COVID-19, intersectional frameworks, intersectionality praxis, Intersectionality-based Policy Analysis (IBPA)

Introduction

The field of public health, with its responsibility to protect and care for the public's health, is routinely involved in policies affecting economics and health. The history of public policies in the U.S. includes stunning successes such as public health efforts to ban smoking in public places, and the widespread availability of potable water and safe sanitation (1, 2). However, public health's track record also includes policy initiatives with mixed impacts on health and wellness, and policies with negative impacts on public health.

Given the regular conflicts between economic and health interests in the field of public health, particularly in countries such as the U.S. with highly privatized healthcare systems, regular reflective analysis of impacts of public health policies is essential (3). With strong economic pressures on public health policy, frameworks for policy review are needed that can help to highlight potential challenges while explicitly incorporating values of equity, intersectionality, multiple time frames and diverse perspectives. While the field of public health has its own understanding of ethics and social responsibility (4, 5) there is a need for a policy

analysis approach that incorporates values and additional perspectives throughout the process to strengthen what public health systems deliver.

The World Health Organization (WHO) has defined health as "a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity", (6) and this definition is widely used internationally. A more recent model proposed by the First Nations Health Authority (FNHA) in Canada, uses a wellness framing, with human beings nested in circles representing (1) the individual, (2) the components of wellness (e.g., spiritual, mental), (3) values that support wellness (e.g., respect, wisdom), (4) the people and places around us that are important for our wellness (e.g., family, land), (5) the social, cultural, economic and environmental determinants of health and well-being, and (6) the people who stand together representing our communities (Figure 1) (7). The FNHA wellness model makes explicit contextual elements essential for health and wellness that are not visible in the WHO definition. The values that support wellness, and the importance of the people and places around us, highlight the multidirectional relationships essential for holistic wellness.

While we might hope for wellness as envisioned in the FNHA approach, an analysis of actual policies provides a lens into what political leaders can deliver. Although public health policies have played a key role in increasing life expectancy and quality of life in the U.S. over the last century, (8, 9) few frameworks have been developed to guide the development of public health responses that are both strategic and data-informed, and also socially humane and equitable. There is a growing awareness of the importance of integrating values such as equity into public health planning, (10) growing out of the documented disparities in health outcomes by race, ethnicity, gender, sexual orientation, and economics (11).

In seeking to understand how varied experiences affect perspectives and experience, the term "Intersectionality" has come into usage to describe the ways systems of power—such as race, gender, sexual orientation, class, and other individual characteristics—intersect to co-construct and constrain individuals' life possibilities. Intersectional approaches highlight the compounded risks and synergistic disparities experienced by individuals impacted by multiple forces of oppression. In outlining the various ways intersectionality can inform public health crises, scholars have noted that intersectionality has disproportionately been engaged as a theoretical framework and analytical tool. Rarely has the framework been utilized in a manner that embodies intersectionality praxis, "the practical application of intersectionality to facilitate equitable health policy and practice for intersectionally marginalized groups, (…) and arguably most essential wave to address the public health crises of our time" (12). Indeed, even as intersectionality has risen in popularity within recent decades, few studies go beyond disaggregating results by subgroups to truly examine the ways systems of power interlock to mutually construct public health outcomes. Even fewer healthcare frameworks exist that embody and advance intersectionality praxis (13).

Although frameworks have emerged to guide health practice, (14) investigations that operationalize intersectionality to analyze and guide current public health policy are scant. One such example includes the work of Hunting (15), who used an Intersectionality-based Policy Analysis (IBPA) to assess Canada's health policy concerning fetal alcohol

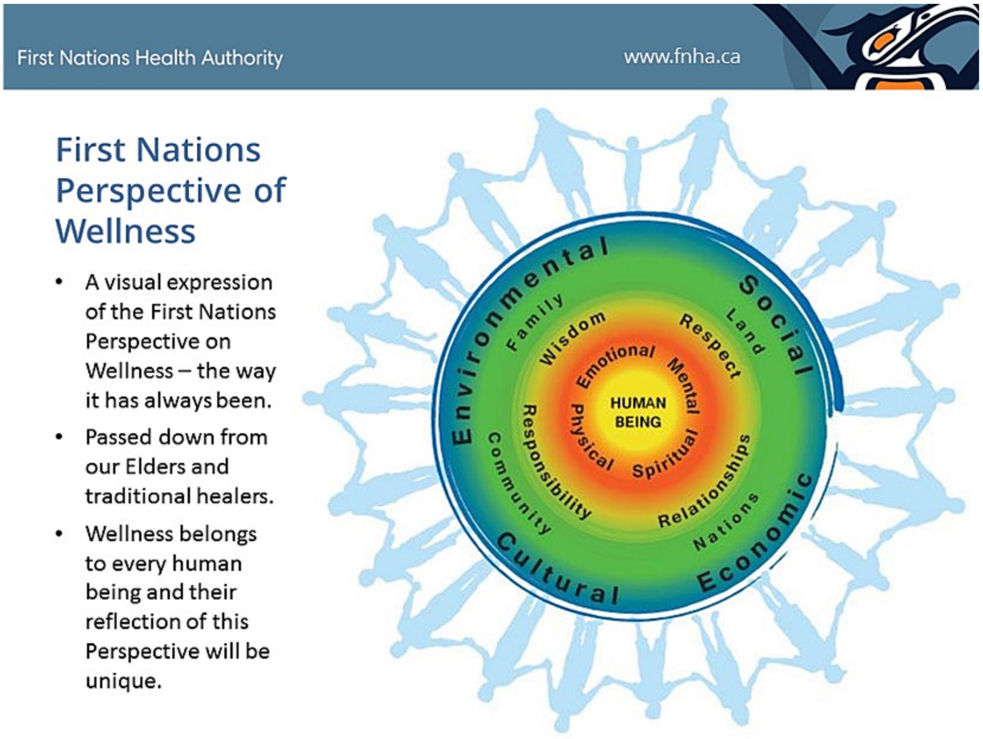

FIGURE 1
The First Nations Perspective on Health and Wellness aims to visually depict and describe the First Nations Health Authority Vision: Healthy, Self-Determining and Vibrant BC First Nations Children, Families and Communities. https://creativelyunited.org/wp-content/uploads/2019/06/FNPOW.png (7) (Used with permission of the First Nations Health Authority).

spectrum disorders. Due to its attention to intersectionality, this study uncovered the ways that the gender and colonial processes interlocked to shape policy and harm Aboriginal women. Fagrell Trygg et al. (16) combined a post-structural policy analysis approach with the framework of intersectionality to analyze a government bill proposing a national strategy on substance misuse and problematic gambling. Adopting an intersectional lens produced wariness regarding the adoption of unidimensional population groups (e.g., women), due to an awareness of different health risks and needs within such groups based on other axes of privilege and oppression (e.g., non-immigrant upper-class women vs. immigrant working class women). These works demonstrate the power of intersectionality-based approaches, especially in their ability to describe how interlocking systems of power create different health outcomes for different groups and also to illuminate the underlying mechanisms (e.g., social processes, structural factors, and policy-decisions) that drive and maintain inequities during times of crisis.

The intersectionality-based policy analysis framework

The Intersectionality-based Policy Analysis (IBPA) framework, developed by Hankivsky and colleagues, utilizes a structured questioning process to consider problems and policy approaches while applying eight guiding principles (17). We offer here an application of the IBPA framework to the early COVID-19 pandemic in the context of racial strife and reconciliation in the U.S., as an example of how the framework can be used to illuminate short, medium and long term solutions to complex problems by addressing both immediate and systemic levers for change. We selected this framework based upon the ways it invites participatory reflection and questioning, with open-ended questions and responses. We were also attracted to the explicit focus on integrating principles of equity, social justice and power throughout the analysis process; such values and areas of emphasis are lacking from most frameworks for policy review. In addition, the IBPA is focused on identifying feasible short, medium and long term solutions, which emphasizes the practical and applied potential impacts of this framework. Finally, as discussed below, COVID-19 related disparities have emerged across various dimensions of inequality (e.g., race/ethnicity, socioeconomic status, gender, sexual orientation, and disability status), including their intersections. Thus, we felt that the IBPA framework might help excavate intersectional problems and solutions that would remain obscured with a framework not explicitly calling out intersectionality.

Unpacking the IBPA framework

The IBPA framework combines eight guiding principles with twelve guiding questions (Figure 2). The eight guiding principles (e.g., power, reflexivity, and intersecting categories) identify values to apply when addressing the questions. The separate series of questions are divided into two categories, descriptive and transformative. Descriptive questions center around ways the policy problem has been described. From there the process shifts to the transformative questions, delving deeper into reframing and explicitly integrating the guiding principles with questions of differential experiences and impacts to reshape understanding and approaches to identify potential solutions. Solutions are then assessed for how they address the roots of disparities and social determinants of health.

To ensure all questions are framed in a way that is congruent with the eight guiding principles, teams utilizing the IBPA framework are encouraged to consider each principle when responding to the twelve guiding questions (Table 1). The two sets of questions, together with the application of the guiding principles, create a novel lens for assessing policy solutions to increase policy impact (17). The structured analytical approach provides an important tool for assessing the impacts of public health policy.

The emergence of a new global pandemic

In late December 2019 reports of a rapidly spreading new coronavirus came out of Wuhan, China. By March 2020 much of the world had restricted travel and human movement to contain the spread of COVID-19. Efforts to curtail the spread had limited success: By December 2020, infections were present in every country, over 83.6 million individuals had tested positive, and more than 1.8 million deaths were attributed to the pandemic globally (7). The U.S. rate of COVID-19 infections was among the worst in the world, with a rate of confirmed infections (>100,000/1 M) in May 2021 that was 11th highest in the world (8). This failure of the U.S. public health system highlights the importance of careful analysis of the U.S. response to the pandemic.

Health disparities in COVID-19

The emergence of COVID-19 had differential effects on the US public based on multiple power-laden demographic factors such as race/ethnicity, gender, socio economic status, sexual orientation, and other dimension of power (13, 19–22). As these systems of power have the ability to compound and interact, public health scholars have called for the greater application of intersectionality to advance equitable policy, surveillance, and intervention related the COVID-19 pandemic (23–25). Further, research has begun to illuminate ways multiple forms of oppression compounded and interlocked to drive unique COVID-related health needs, barriers, and outcomes among multiply-marginalized populations (26–29).

The COVID-19 pandemic was not unrelated to the racial crisis within the U.S. (30). Indeed, early on within the pandemic, it became clear that each of the key health outcomes (e.g., infections, hospitalizations, and deaths) mirrored larger trends within U.S. health disparities, with people of color carrying a disproportionate burden. Second, on May 25, 2020, amidst the ongoing COVID pandemic, a White police officer, Derek Chauvin, knelt for 9 min and 29 s on the neck of George Floyd, a Black man, while he struggled to breathe. George Floyd was killed, and the cellphone recording of his death galvanized communities and individuals around the U.S. Rallies took place in hundreds of communities, as millions marched to say that Black lives in the U.S. have been disregarded for centuries. The death of George Floyd, and the movement growing out of it, highlighted the disparate experiences of White and Black individuals within American institutions, including the health care system.

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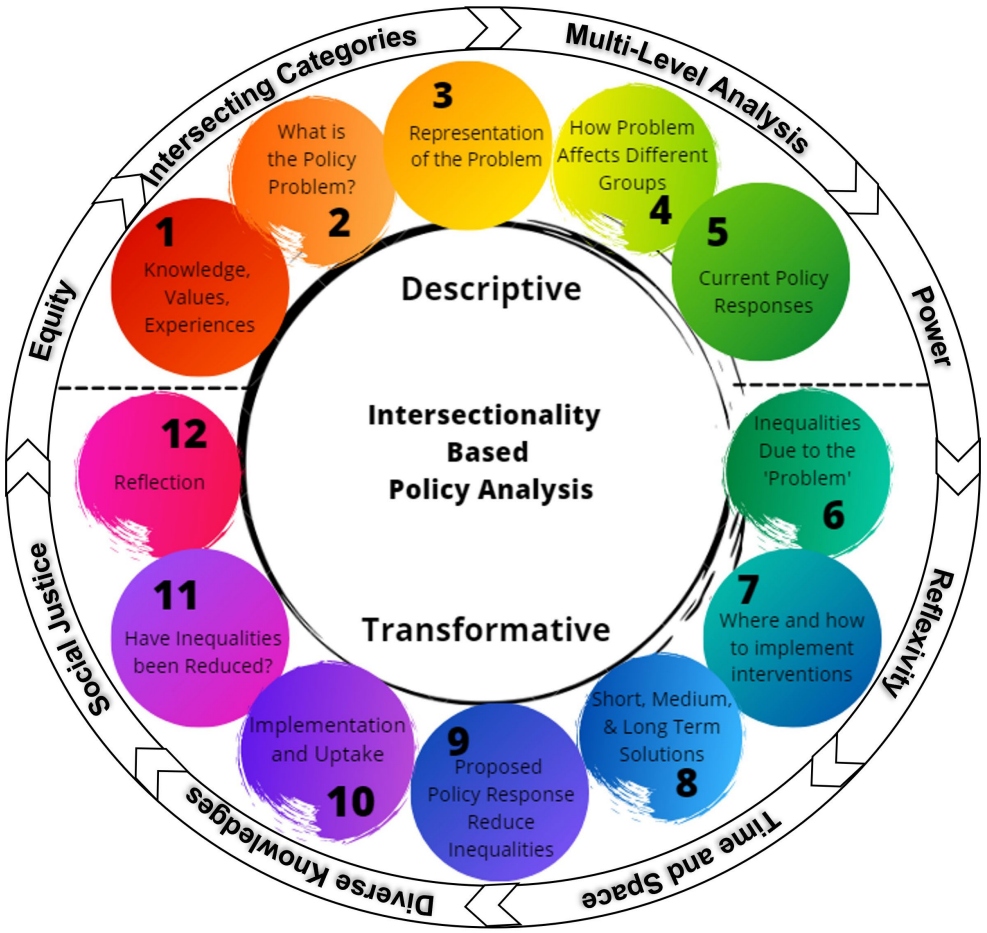

FIGURE 2
The components of the Intersectionality-based Policy Analysis Framework, including the five descriptive questions, seven transformative questions, and the eight guiding principles that encircle all of the questions (*submitting for creative commons licensing*).

This article utilizes the shared experience of the COVID-19 pandemic from March to November 2020[1] to assess the utility of the IBPA for public health policy analysis. While the focus of the article is the IBPA framework and process, the article applies the IBPA framework and an intersectional lens to the COVID-19 pandemic to determine whether this approach might provide additional insights into the dramatic policy failures that led to >400,000 Americans dying in the first year of the pandemic.

Methods

Application of the IBPA framework

The framework was used as a logical structure for evaluating the March–November 2020 COVID-19 responses of the U.S. local, regional, state and national governments charged with public health services and protections. Responses to the pandemic were identified from real time news reports as well as World Health Organization and Centers for Disease Control updates. We drafted and revised responses to each of the twelve questions and sought feedback from colleagues, expanding responses as needed to apply the IBPA framework and capture possible responses around the COVID-19 pandemic. We therefore added an additional question 5a (how are policy responses represented in media and public statements), as our discussions brought to light the importance of explicitly noting the role of the media in politicizing policy responses. With repeated feedback and critical reflection, responses to each question within the framework were developed, clarified, and refined.

Results of the analysis

The COVID-19 pandemic provides a useful example of what happens when there are widely divergent representations of a policy problem. By differentiating between a policy problem (e.g., high rates of COVID transmission within the US) and subjective representations of a problem (e.g., COVID is a hoax) the IBPA provides useful insights into how framing influences and shapes policy responses. By adopting

1 We chose to restrict analysis to before vaccines were available in December 2020.

TABLE 1 Guiding Principles for IBPA [adapted from Hankivsky (18)].

guiding principles	Definition and application
Intersecting categories	One social category cannot fully define or explain an individual's needs and experiences. Intersectionality recognizes that multiple categories underlie each of our lived experience. *Example: In responding to Q6, applying the guiding principle of intersecting categories drew attention to low-income immigrants of color in jobs that could not be performed remotely who were particularly impacted by the pandemic.*
Multi-level analysis	Relationships and associations happen across multiple levels of society and across policies (from the micro to the macro) that can reinforce inequities *Example: In response to Q5, authors addressed the evolution of policies such as stay at orders which impacted individuals of various levels of society differently.*
Power	Systems of power have been used across structural levels (local, federal, global) as a means to instigate and enforce inequities. IBPA prioritizes recognition of how power can be resisted, replicated, and modified to dismantle systems of inequities. *Example: In response to Q10, authors noted key stakeholders and relevant decision makers that hold power when determining how implementation and uptake of suggested policy responses and solutions.*
Reflexivity	Reflexivity reminds researchers, stakeholders, and policy makers to practice self-awareness, recognize positions of privilege, and conduct continual conversations concerning these topics. *Example: Responding to both Q1 and Q12 encouraged authors to take a step back and acknowledge their limited knowledge and position of privilege, and to consider insights from applying the intersectionality based policy analysis.*
Time and space	Understanding of the world, societal structures, individuals, and identities are rooted in specific places and times. *Example: In response to Q7 & Q8 authors considered how policies may impact individuals at varying levels of society and different geographical areas over time.*
Diverse knowledges	Validation, recognition, and inclusion of voices and experiences of groups, especially of those that have historically been marginalized, is vital to addressing inequities and dismantling systems of power. *Example: In response to Q4, diverse knowledges of the authors encouraged varying opinions and attentiveness to news and scientific articles coming from different viewpoints, such as those who do not rely on currently accepted scientific evidence as means to combat COVID-19.*
Social justice	Social justice aims to find methods to dismantle inequity in social structures and policies. *Example: In response to Q9, applying the guiding principle of social justice to this question encouraged consideration of multiple areas of inequities in identifying polices.*
Equity	Equity challenges stakeholders and researchers to consider what polices can achieve fairness and justice regardless of privilege and oppression. *Example: In response to Q11, application of the guiding principle of equity allowed authors to consider how to capture changes in equity.*

an intersectional lens more nuanced policy considerations and options emerged. Here we consider the process and experience of responding to the questions and particularly the guiding principles brought to bear on the process.

While we provide examples of how specific components of the IBPA can be applied (Tables 1, 2), in the results we focus on the process of completing the IBPA.

Guiding principles

The team drew on each of the eight guiding principles in completing the IBPA. Table 1 gives illustrative examples of how the guiding principles informed the process. For example, in considering the principle of reflexivity the authors named their own positions of privilege and identified limits to their own knowledge in responding to the questions.

Descriptive questions

After reflecting on the knowledge, values and experiences the authors bring to this area (Q1), we developed a concise statement of the problem "*Slowing/controlling transmission of a highly contagious infectious disease transmitted through respiratory, aerosol and contact routes by asymptomatic and symptomatic carriers*" (Q2). This definition highlighted the policy challenge, slowing transmission, based on what was known early on about the virus (See Table 2A).

In considering Q3 ("*How have representations of the problem come about?*"), we were struck by four different elements of how the problem is presented: who is at risk? how serious is the risk? what policy options are possible or appropriate? and what data is available and trusted to draw conclusions about the problem? These areas arose as we applied the principles of equity, power and social justice to the question concerning different representations of the problem. In each of these areas the response highlights the absence of a definitive U.S. statement, and dramatic variation in representations of risk. Based on representations of who is at risk, different stakeholders, together with different states, counties, and cities, proposed varied policy responses (Q4). Underlying the different representations are different political perspectives and reliance on different data about the emerging and ongoing pandemic.

After looking at differential impacts of the representations of the problem, questions four and five encourage a close look at the spectrum of impacts, and the ways the representations of the problem (e.g., risk to

TABLE 2 Application of the Intersectionality-based Policy Analysis framework to the COVID-19 pandemic.

A: Descriptive questions	
1. What knowledge, values, and experiences do you bring to this area of policy analysis?	1.1 Knowledge: Public health; infectious and chronic disease epidemiology; psychology; determinants of disparities in health risks and outcomes; feminist, decolonial, queer, and other social justice perspectives on health justice. 1.2 Values: Redressing historical inequities; norming processes that embody equity for all individuals and communities; intersectionality; community-focused and community-driven public health. 1.3 Experiences: International and U.S.-based experiences of culture of disparity and white supremacy (all); living in poverty in the U.S. (DLH); being a Black first generation African woman in the U.S. (MS); experiencing intersectional stigma as a Black queer individual (SDJ).
2. What is the policy 'problem' under consideration?	The national challenges associated with quickly, equitably, and sustainably slowing/controlling the transmission of a global, highly contagious infectious disease transmitted through respiratory, aerosol and contact routes by asymptomatic and symptomatic carriers.
3. How have representations of the 'problems' come about? *We explored representations of three components of the COVID "problem": Who is at risk, what policy options are possible or appropriate, and what data is available and trusted to draw conclusions.*	3.1 ***Who is at risk:*** a. Initial U.S. representation was that it was a problem limited to travelers from China and large urban centers; this has remained the perspective of some groups. Trump said "Risk is very low (2/26)." b. As awareness grew of (1) community spread, (2) risk among all age groups, (3) impact of comorbidities, and (4) asymptomatic and pre-symptomatic spread, the scientific community's representation evolved into a problem facing entire communities, with some groups at increased risk. c. An additional representation that the virus is nothing to worry about and a political stunt by anti-Trump groups. "They tried the impeachment hoax. This is their new hoax." (Trump – 2/28) (31) 3.2 ***What policy options are possible or appropriate:*** a. Competing representations are highly politicized, one extreme that (a) there is little the central government can do so we need to learn to live with the virus until a vaccine is available, and (b) this is a deadly threat and government-motivated population mobilization to stop the spread is essential. b. Limited discussion of longer-term policies such as reducing habitat destruction and deforestation that address social practices that may heighten risk of coronavirus (and other emergent pathogens) outbreaks. 3.3 ***What data is available and trusted to draw conclusions about the problem:*** a. Multiple groups developed highly sophisticated public mapping and monitoring systems that reported case burden and other key statistics on a daily basis. Such public data was most often presented on websites of universities and traditional news outlets such as the New York Times and Washington Post, sources not trusted by many viewers of conservative media such as Fox News. b. White House changed hospital data reporting protocol from the Centers for Disease Control to the Department of Health and Human Services, and linked reimbursement to use of the new reporting system, making some data less available to the scientific community (32).
4. How are groups differentially affected by this representation of the 'problem'?	4.1 With initial representations of limited risk, people with symptoms without contact with travelers from China could not get tested, and people whose symptoms did not align with the criteria were often unable to get tested. 4.2 As awareness of community spread grew, ***those who accept the perspective of the scientific community*** made efforts to follow guidelines such as maintaining distance from others, wearing masks and handwashing. These recommendations, emerging from the representation of the problem driven by the scientific community, led to greatest impact on older adults and others needing caregivers, as well as people (a) with low income, (b) working at home while supporting children who are learning online, (c) with limited access to the ability to work or learn online, (d) who live in high housing density, (e) who must work, and (f) with occupational requirements to interact closely with others. While the initial risk was in urban settings, this changed over time. There was an observed association between higher geographic risk and (a) job categories that do not allow working from home and (b) people of color. 4.3 ***Those who do not fully accept the perspective of the scientific community*** resisted local government efforts to require masks and social distancing practices, leading to protests in some communities and states.

(Continued)

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TABLE 2 (Continued)

A: Descriptive questions	
5. What are the current policy responses to the 'problems'?	5.1 Recommendations from government and scientists first focused on stopping transmission by (a) shutting down exposure through travel and movement in public spaces, (b) reducing risk in older adults and other highest risk groups and (c) monitoring for symptoms. 5.2 Policy responses evolved to include: physical distancing[a], masks, physical closing of schools, workplaces and businesses; limiting both international and domestic travel; varied levels of mandates and/or guidelines for 'safe' opening by state (and country), highly varied enforcement; within U.S., high levels of state and (sometimes) local autonomy in making decisions about guidelines for opening schools and businesses. Sovereign Native American Communities instituted curfews and lock downs, with checkpoints and monitoring at tribal boundaries. 5.3 Rapid investment, development and roll out of technological responses such as pharmaceuticals and vaccines, which has led to regular updating of perceived efficacy of different treatment and pharmaceutical approaches.
5a. How are the policy responses represented in media and public statements?	Masks, while initially presented as unnecessary, with the onset of the pandemic and stay at home orders were presented as life-saving by scientists, state and local governments and public health professionals, and as a violation of freedom by other constituencies. The day after the CDC rolled out their roadmap for re-opening after stay-at-home orders across the country, Trump tweeted "liberate Michigan." (4/17) (31) Stay at home orders are too costly (33) and the cure is worse than the disease
B: Transformative questions	
6. What inequalities actually exist in relation to the "problem"?	**This list is not all inclusive**. However, ***disparities that have been magnified due to the pandemic*** have been listed with some examples for clarification. Listed disparities are meant to emphasize how various disparities are intersectional in nature and cannot be mutually exclusive. 6.1 **Disparities in people's risk of being exposed** (keeping people physically separate unless protected by personal protective equipment (PPE)) – disparities in employment and living situations that affect an individual's ability to stay physically separate from others and still meet basic needs. Exposure disparities were exacerbated by pre-existing racial, ethnic, gender, socioeconomic and geographic disparities 6.2 **Disparities in ability to isolate and avoid exposing others** (isolating exposed and sick people) – disparities in individual, household and community resources that are needed to support such isolations; these disparities were particularly driven by socioeconomic and racially based differences in employment opportunities. 6.3 **Disparities in access to clinical resources to speed healing and reduce additional spread** (access to culturally relevant and linguistically appropriate medical services) – disparities in individual, household and community access to health care resources to respond to infection. These disparities were enhanced by racial, ethnic, and socioeconomic class differences in employer-provided health insurance, sick leave and other workplace policies. 6.4 **Disparities in background health conditions** – severity of infection varies with a number of background health conditions such as asthma, diabetes, hypertension and obesity that are unequally distributed across racial, social and ethnic lines. There are strong racial and ethnic disparities in background health conditions across the United States (20, 34).
7. Where and how can (immediate) interventions be made to improve the problems?	7.1 **Physical distancing, masks and improving air flow in tandem with socioeconomic supports**. Improving air flow with barriers and filters can slow the spread among those able to comply, and socioeconomic supports are essential to reduce socioeconomic barriers to compliance, while regulation/requirements are needed to compel compliance. 7.2 **Rapid testing for both symptomatic and asymptomatic individuals, paired with contact tracing** allows real time monitoring and control of infections. Testing supplies and clinical laboratory facilities are needed to provide rapid testing; education, personnel and data management systems are essential for smooth functioning of the contact tracing system. 7.3 **Government sources provide (national) consistent, clear, and accurate information tailored to the needs of specific communities.**

(Continued)

TABLE 2 (Continued)

B: Transformative questions	
8. What are feasible short, medium and long term solutions?	8.1 ***Short term:*** a. Social supports for physical distancing b. Application of evidence-based guidelines on engineering approaches to reducing transmission c. Medicare/Medicaid for all for Covid-19 care d. Widespread rapid testing and contact tracing (35) e. Work on development and piloting of communication campaign 8.2 ***Medium term:*** a. Access to affordable, rapid, highly sensitive home tests b. Continued social and governmental buy-in for socioeconomic supports and engineering approaches (which include masks) c. Continuing vaccine development, testing and equitable distribution d. Address media illiteracy and widespread media manipulation and spreading of inaccurate and misleading statements, which are undermining understanding of the disease and the infection and exposure risks. We need an effective public health communication campaign that accurately and simply explains (a) risk and (b) effective behaviors. 8.3 ***Long term:*** a. Rethinking of the goals of public health system in the United States to include an exploration of an equitable social contract (36). b. Access to quality health care systems regardless of geography and economics – models of funding for quality health care (11). c. Review and strengthen infection control and staffing requirements in all group and long-term care facilities (37). d. Review inequities in educational system that have created tiers of educational access and differential job access, which translated into differences in ability to adapt to physical distancing guidelines and differential economic impacts. e. Strengthen understanding of the essential nature of environmental systems for human sustainability and health – e.g., habitat destruction, ecosystem services, safe housing, living wage. f. Strengthen measurement and effective dissemination of research-based information on health disparities to the public across multiple categories (race/ethnicity, class, geographic location, age, etc.). g. Systemic changes in the medical system and medical education system (38–40), including the elimination of various forms of bias, discrimination, and dehumanization (e.g., racism, classism, sexism, heterosexism). h. Systemic changes in generation of evidence base in medicine and public health. i. Increasing under-represented minority (URM) healthcare workers, in order to reduce medical mistrust and improve culturally attuned relationships between communities of color and healthcare providers. j. Building a public culture that understands the importance and role of ambiguity in science. k. Strengthening awareness of the need for restorative health justice given the history of injustice in the health care system
9. How will proposed policy responses reduce inequities?	Policy responses identify immediate intervention opportunities, while also highlighting the need for a long-term vision of sustainable and equitable change. By addressing social determinants of health, policies have the opportunity to take into consideration the conditions that people are born into, and the environments where they live and work. The aforementioned proposed policies in Q.8 have aimed to take into consideration: 9.1 Socioeconomic Status 9.2 Race and Ethnicity 9.3 Transportation 9.4 Place of Residence 9.5 Educational Literacy 9.6 Access and Use of Health Services The aim of the policies will be to encourage government and public service organizations to provide resources that allow individuals from various backgrounds to have a health equity-based approach in addressing COVID-19.
10. How will implementation and uptake be assumed?	Solutions will need individualized roadmaps, identifying key stakeholders and relevant decision makers, as well as points of leverage and key constituencies. Outreach for all solutions will need to be through multiple channels, which could include the National Association of City and County Health Officials, National Association of Governors, Centers for Disease Control, National Institutes of Health, social media (e.g., tiktok, videos with masks and how to live with other recommended guidelines, images, memes), media, sports and entertainment figures.

(Continued)

TABLE 2 (Continued)

B: Transformative questions	
11. How will you know if inequalities have been reduced?	11.1 Reduction in disparities in rates of cases, hospitalizations and deaths of people of color and low-income individuals from COVID-19 11.2 Reduction in medical misinformation dissemination 11.3 Increase in access to medical information (culturally responsive, linguistically appropriate, regardless of urbanicity) 11.4 Increase in populations' access to care 11.5 Reduction in medical mistrust 11.6 Greater adherence to CDC guidelines on physical distancing in various spaces (outdoor and indoor) 11.7 Reductions in disparities in underlying chronic health and economic conditions
12. How has the process of engaging in an Intersectionality-based Policy Analysis transformed: your thinking about relation and structures of power and inequity; the ways in which you and others engage in the work of policy development, implementation and evaluation; broader conceptualizations, relations and effects of power asymmetry in the everyday world	Process has highlighted tightly linked structural disparities and the need for a very long term perspective, as well as a short term focus on immediate actions. Through applying the IBPA we came to see the value of the IBPA questions for intersectional praxis – for proposing short, medium and long term innovations/interventions to address the intersectional experiences of inequities in the public health and medical care systems. 12.1 We encourage others to repeat the process of responding to these questions as a group, to identify contextually appropriate solutions, noting the value of different points of view to this process 12.2 We note the embeddedness of historical thinking that includes (a) top down public health approaches and (b) declaring war on particular pathogens, and the way in which top down approaches are not functioning right now in the United States 12.3 We note the need to include a broader group of stakeholders in this analysis and decision making 12.4 This process has highlighted the flaws in the academic system of the emphasis on metrics such as publications and grants, with less support for long-term relationship building needed for systemic and political problem solving 12.5 Process has encouraged thinking about relationships and structures of power and inequity, with a focus on nested circles of power and inequity, and the need to better highlight effective solutions at all levels

[a]While the language of social distancing has been used extensively in the pandemic response, the term is unfortunately similar to the sociological construct of social distance, which refers to differences in class and social status. Thus, we have chosen to use the alternative term, "physical distancing".

travelers from China, risk to older adults, just a mild flu) impacted behaviors and practices in the general public and in the health system (e.g., who could get tested, what personal protective practices were recommended, and what civil policies were enforced on masking). An additional consideration included how media and statements by public officials represented the varied policy responses.

Transformative questions

The transformative questions are designed to incorporate longer-term social and structural determinants into the analysis, encouraging consideration of how longer-term factors may be affecting the situation and how policy options could simultaneously address root causes of disparities (see Table 2B).

By drawing out disparities with respect to the policy problem, Q6 ("*What inequalities actually exist in relation to the 'problem'?*") encourages a breadth of reflections. We considered inequalities across the life cycle of an infection, through the stages of exposure, susceptibility, access to care, response to treatment and further transmission, and disparities in background health conditions that have been observed to increase risk of serious disease. At every stage there were multiple, intersecting psychosocial, behavioral and biological factors affecting compliance with recommended protective behaviors. These include mistrust of health care professionals, history of discrimination leading to lower economic resources, poor nutritional status and greater immunological susceptibility, and cultural differences in households such that individuals living in multigenerational households were at increased risk of transmission when compared with individuals living alone. Utilizing the wide-angle intersectional lens helped to highlight the importance of different household and family structures for transmission and risk, and the need to develop flexible policy responses that address the spectrum of needs.

Q7 ["*Where and how can (immediate) interventions be made to improve the problem?*"] identifies immediate interventions while considering the guiding principles. We found the guiding principles of multi-level analysis, social justice and intersecting categories to be particularly relevant, as these principles ensure that efforts taken to achieve a larger policy goal do not simultaneously exacerbate existing disparities. Some of the interventions suggested (see Table 2B) were under local or private control, impacting businesses, schools, institutions or municipalities, while other interventions such as testing and contact tracing might involve coordination across multiple governmental levels.

Q8 ("*What are feasible short-, medium- and long-term solutions*") builds on Q7, encouraging thoughtful consideration of short-, medium- and long-term solutions. The distinction between immediate interventions in Q7 and short-, medium- and long-term solutions in Q8 emphasizes integrating long term systems change solutions that can incorporate respect for diverse knowledges, reflexivity, time and space. These values are reflected in our response to Q8, where we suggest that consideration of the objectives of the public health system in the U.S. are needed to identify and implement long term solutions to problems such as COVID-19. Suggestions for long term solutions are quite broad, including changes needed in educational systems, how evidence is generated in medicine and public health, and improving infection control requirements within care facilities.

Q9 ("*How will proposed policy responses reduce inequities?*") asks for the evidence that the proposed solutions in response to Q8 will reduce inequities. We have identified existing evidence suggesting connections between the proposed solutions and redressing inequities, while also encouraging ongoing assessment. This includes the assessment of our previously identified solutions. We chose to include some innovative approaches that may not yet have generated evidence of their ability to address inequities, given the importance of innovative approaches to address inequities.

Q10 ("*How will implementation and uptake be assumed?*") focuses on implementation and uptake, highlighting that without thoughtful implementation plans solutions are rarely effective. Our response notes the importance of individualized road maps for different solutions that will need buy-in from leadership and policy makers across sectors and levels.

Q11 ("*How will you know if inequalities have been reduced?*") builds on Q9, seeking identification of clear markers of existing inequities and ways to monitor changes. Reductions in disparities along the COVID-19 continuum (e.g., transmissions, hospitalizations, and deaths) would highlight the effectiveness of the policy proposals.

Q12 ("*How has the process of engaging in an IBPA transformed: your thinking about relation and structures of power and inequity; the ways in which you and others engage in the work of policy development, implementation and evaluation; broader conceptualizations, relations and effects of power asymmetry in the everyday world?*") is a capstone question demanding detailed and systemic analysis. Participants are invited into a broader reflection of how the process has transformed ideas and thinking. For example, our experience provided reinforcement of the tight connections between structural disparities in the economic, education and health care systems with the disparities in health outcomes.

Discussion

Since the onset of the COVID-19 pandemic numerous articles have been written about the differential intersectional impacts of the pandemic (21, 22, 26, 27). Authors have highlighted differences in outcomes by intersectional dimensions such as sexual orientation, (22, 27), race/ethnicity (21, 22, 26, 27), and gender (21). However, few have used a full intersectional approach as recommended by Maestripieri, bringing the lenses of age, race/ethnicity, gender, sexual orientation, and socioeconomic status/class to analysis of impacts of the COVID-19 pandemic (24). In addition, research is focused on what Bowleg calls the third wave of intersectionality, analysis of intersectional issues, with few articles moving beyond analysis of impacts to Bowleg's fourth wave, of intersectional praxis (12). While some studies include suggestions for intersectional praxis, with intersectionality informed recovery strategies (21) and COVID-19 vaccine distribution plans, (28) this article provides a unique example of a praxis-focused analysis that can be brought to bear across the full spectrum of intersectional concerns and can be applied to many program and policy issues.

Our analysis used the IBPA approach to unpack the early U.S. response to the COVID-19 pandemic to assess what insights this approach might give into the dramatic policy failures that led to more than one million Americans dying over the three years of the pandemic (41). Our iterative engagement with the framework's structured questions and guiding principles raised considerations and stimulated ideas that otherwise may have remained obscured. This illustrative test of the framework's utility in developing humane, data-driven solutions to contemporary public health problems can serve as a guide for other researchers and policy makers who are interested in using this framework to improve health outcomes.

The detailed questions and guiding principles of the IBPA framework invite identification of upstream drivers of disparities and a long-term perspective, with identification of feasible short-, medium- and long-term solutions (Q8). The wide-angle lens invites consideration of the broader nested influences such as in the FNHA wellness model (Figure 1). That broader perspective, in combination with the guiding principles of equity, social justice and diverse knowledges, highlighted structural (e.g., socioeconomic class differences in employer-provided health insurance, sick leave and other workplace policies), social (e.g., medical mistrust among communities of color), and environmental (e.g., habitat destruction) determinants and modifiers of policy and health impacts.

The strengths of the IBPA include the direct questions in combination with the guiding principles, as well as flexibility in the identification of questions most relevant in particular policy analyses. For example, the differentiation between the myriad representations of the problem and the actual problem enabled thoughtful considerations of the importance of media representations in addressing solutions. The framework requires consideration of evidence and data (e.g., asking for the existing evidence that the proposed solutions will work) without sacrificing attention to equity and fairness (e.g., asking how groups are differentially affected). This multidimensional focus is more likely to generate recommendations that harmonize science, strategy, and social justice to inform health policy. This process also lends itself to inclusion of a diverse group of participants, and inclusion of diverse stakeholders is important to capture a rich combination of policy responses.

We see the IBPA framework as a highly relevant tool for intersectional praxis (42). Identifying drivers of policy problems and modifiers of policy impacts. The IBPA framework and process is a useful tool for reimagining public health in light of the COVID-19 pandemic as researchers have called for (43). This framework can be implemented across a range of policy levels, from an organizational analysis to a governmental analysis. The IBPA framework was particularly useful in differentiating between actual problems or policies and how the problem or policy is being represented, along with generating implications of various representations for different groups. The explicit inclusion of short, medium and long-term solutions is an important reminder of the need for a long-term vision of the public health system while working on shorter term change.

We noted some limitations to the IBPA framework and process, including the emphasis on evidence—a term that is increasingly contested, due to implicit notions of what does (and does not) suffice as evidence within the scientific domain (44). Also, while we agree considering existing evidence is important, we also note that evidence derives from past research—thus, an emphasis on evidence can hamper innovation and novel ideas. Second, we note the flexible nature of this framework and the need for commitment and expertise in applying the values, which may lead to results that vary in rigor and content across researchers. While we appreciate the flexibility of the guiding principles, we also found it challenging to prioritize them to address particular questions. Understanding the different guiding

principles, such as reflexivity, diverse knowledges and time and space, takes skill and specialized knowledge.

Conclusion or synthesis

We are at a pivotal point in U.S. history, when contradictory opinions about the responsibilities and rights of government are being expressed and policy discourse is often focused on short term solutions. The public health system, and public health professionals, have long stood for the importance of fair and equitable supports for health for all (11, 38). The IBPA framework is a tool that can be used to design and build a more robust, socially-responsive public health system that better addresses the complex upstream determinants of health disparities in the U.S. and elsewhere (25). The IBPA framework encourages bold thinking and a commitment to build the resilient and socially just public health system our communities need.

Author contributions

DH and MS identified the analytical approach and framework for this work. MS developed the tables and figures. DH drafted the initial manuscript. DH, MS, and SJ contributed to the ideas, revised the tables, figures and manuscript and contributed significantly to the writing. All authors contributed to the article and approved the submitted version.

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Conflict of interest

The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.

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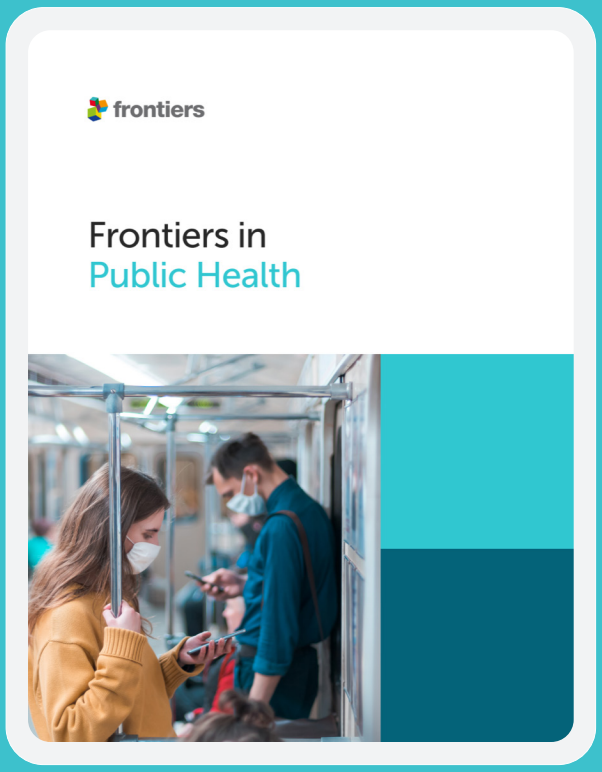

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