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Health service management and leadership: COVID-style

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Health service management and leadership: COVID-style

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Editorial: Health service management and leadership: COVID-style

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Editorial on the Research Topic
Health service management and leadership: COVID-style

COVID-19—the term that changed the world. The COVID-19 pandemic shaped our personal lives, our professional lives, our educational and recreational pursuits, as well as how we die and grieve (1–3). However, arguably, no one was affected more than those who deliver, manage, and receive healthcare, *senso lato*. For instance, following government and organizational directives, the pandemic influenced: who can interact with whom; when they can do it; and how, including the information they are (not) privy to, the resources they can(not) access, and when. These changes can compromise the organizational practices of a health service, morale, and the wellbeing of those affiliated with the service, such as staff members (including volunteers) as well as patients and carers.

Although change within health services can be slowed, if not stopped by bureaucracy and politics (among other factors), COVID-19 illustrated how swiftly change can happen in health services in the face of a global crisis. The world quickly became a village, as organizations across the government, university, private, and not-for-profit sectors collaborated and colluded to navigate and manage the pandemic. This might have been partly helped by similar challenges that many nations and health systems share, including aging populations (4), the increasing prevalence of complex and chronic disease (5), the rising cost of healthcare, and limited capacity within the healthcare workforce, fuelled by burnout.

However, COVID-19 also amplified the differences between nations and health systems. Consider, for instance: the different shades of government involvement in healthcare—while some nations benefit from a healthy public health system, others do not (6); the disparate access to resources, partly due to varied degrees of investment in research and development, as well as supply chains; the different degrees of public trust in government (7); citizen engagement in public health efforts; the cultural richness of the nation, particularly the presence of First Nations peoples and people of culturally and linguistically diverse backgrounds; geographical terrain, and the proportion of citizens who reside in rural, regional, and remote areas; and the leadership styles of those leading nations or the health services, therein.

In response to the rapid spread of COVID-19, this Research Topic represents a complement of formative and thought-provoking articles that collectively advance the research and practice of health service management and leadership. The Research Topic offers opportunities to capture, learn from, and inspire managerial and leadership practices that have helpfully

navigated this precarious period. It includes international exemplars to demonstrate what it takes and can take to manage and lead a health service to ultimately weather storms, like COVID-19.

The importance and urgency of this Research Topic follow extant research, from which three key points are apparent. First, there are likely to be COVID-like pandemics in the future, partly due to the Anthropocene epoch (8–11). Second, although health services are certainly familiar with, if not accustomed to crisis management, many are ill-prepared for the system-wide effects—if not, seismic shift—associated with instances like COVID-19. Third, relative to clinical research, there is limited scholarship on how to lead and manage health services during global pandemics.

The Research Topic is comprised of myriad article types, collectively presenting arguments about health service management and leadership during the COVID-19 pandemic. For instance, in their brief research report, Guo et al. demonstrated the use of virtual models to redesign the intrahospital transportation of patients thought to have COVID-19 to ultimately curtail transmission. Processes were also the focus of a scoping review—specifically, Best and Williams considered healthcare supply chain management and how personal protective equipment is sourced during pandemics. They concluded that, although little was learnt from previous pandemics, and despite the paucity of research from low- and middle-income nations, "planning… collaboration and relationship building" are pivotal when sourcing personal protective equipment during a pandemic. Dadich and Mellick Lopes also contributed a review—however, theirs is a lexical review; that is, an analysis of discourse to determine how words travel together. Following their lexical review of 36 articles on leadership during a pandemic, they offered two key findings—"First… leadership discourse was often associated with a single leader, rather than multiple leaders… This reinforces the way in which leadership is often attributed to an individual, rather than to a team of leaders". Second, discourse about leadership was "somewhat disconnected from… stakeholders, including colleagues and patients, and relationships with these stakeholders". Given these findings, they argued that there were considerable opportunities to advance scholarship on leadership during a pandemic. Naamati-Schneider and Gabay also considered the power of discourse—specifically, they examined metaphors of war in effective and ineffective coping among medical directors of COVID-19 wards in public hospitals. They found that "Effective coping was facilitated by war metaphors that created a sense of mission and meaningfulness at both the organizational and the individual levels. War metaphors that generated a sense of isolation and sacrifice intensified helplessness and fear, which undermined coping". Their research has important implications for how information about pandemics is communicated and how others support can be bolstered and sustained. Specifically, they argued for "metaphors, analogies, and words that emphasize ideology and values that empower (heroism, cohesion, comradeship)"; furthermore, they proposed "avoiding metaphors, analogies, and words that emphasize distress and isolation".

Like Naamati-Schneider and Gabay, others also contributed original research. Consider, for instance, Petrie et al.'s ethnographic research to investigate innovation in rural health across four nations. Among their findings, they discovered the value of "absorptive capacity… community connections, and… some level of ignorance of the barriers to innovation". Yet they called for future research to "understand how vulnerable or marginalized populations were supported, and to see how local services managed their relationships with provincial health departments, distant specialists, and other external actors". In their original research article, Di Pumpo et al. demonstrated the value of queueing theory to maximize safety at, and the performance of COVID-19 vaccination sites. Notably, they verified how modeling premised on queueing theory helps to "quantify ahead of time the outcome of organizational choices on both safety and performance". Dellve and Williamsson also offered original research to this Research Topic through their investigation of development work in aged care. Specifically, they considered "ongoing development work at the strategic and operational levels, noting the importance of this work for trustworthy operational management work". They found differences between strategic-level development leaders and operational-level leaders. While the former "focused the strengthening of old adults' capabilities", the latter "approached strengthening employees' capability". Given aging populations worldwide and, relatedly, the growing strain on aged care services, this study has direct international relevance. Qian et al. offered the last original research article, the focus of which was a comparison of government policy and community participation to manage the spread of COVID-19. This interesting study concluded that government policy and community participation assumed different roles at different times—"although the government played a leading role in setting up policies, the broader participation of community fever clinics… and the general public were especially crucial in winning the battle against COVID-19 in the long run".

Complementing the aforesaid articles are perspective and opinion articles. The perspective articles include that by Lee and Wong who argued that, to manage a global pandemic, governance arrangements are required that "enable organic and responsive processes for all actors in society"—this can include hybrid modes where "(1) the state… undertakes coordination based on the consensus of actor-networks, (2) the market… is repurposed with a high-risk investment of the state, and (3) the network… is steered by traditional principles of public governance". Amu et al. offered another perspective article focused on sub-Saharan Africa. They contended that "Long-lasting abysmal health system financing and insufficient government investment… pose major challenges to the effective health systems functioning amid the COVID-19 pandemic"—furthermore, they called for research to examine and improve responses to COVID-19 in sub-Saharan Africa. Finally, Balconi et al. co-authored an opinion article on monitoring strategies and intervention policies to enhance and protect advanced neuroscientific research, post COVID-19, in Italy. Drawing on an applied example—the MIRNA project—the authors demonstrated the value of a uniform approach to reinstate pre-pandemic practices. The example revealed the benefit of "standardized and shared practices… to ensure that R&D [research and development] overcomes this crisis and potential future challenges, while also protecting the public health and all actors involved in the strategic research field of basic, clinical and applied neurosciences".

Each contribution to this Research Topic highlights international efforts in response to a common challenge—COVID-19. And given the prospect of future pandemics, the value of the lessons presented in this Research Topic are likely to have value in the longer term. In the interim, the challenge for scholars, policymakers, as well as those who deliver and manage healthcare is to advance current understandings of health service management and leadership, to ensure that we garner and build on what we have collectively learnt through this international experience.

Author contributions

AD wrote the editorial. SB, GM, and TW reviewed and approved the editorial. 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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COVID-19 Responses of South Korea as Hybrids of Governance Modes

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The countries worldwide have adapted diverse governance approaches to the pandemic to suit their contexts. While the diversity of the country-specific governance responses has been widely discussed, the hybrids nature of those governance practices has been explored less. This study analyses the responses toward COVID-19 in South Korea as responsive dialogues of different modes of governance, i.e., consensus-based hierarchy, state-sponsored market, and principle-based network. This study aims to remind us that pandemic governance needs to enable organic and responsive processes for all actors in society. This conceptual discussion of the governance modes illustrates that the pandemic allowed the emergence of the hybrids of governance modes to cope better with the complex realities of the diverse sectors and actors in South Korea. The characteristic of the responses diverges from the conventional governance classification of or market-based. It is a responsive and evolving dialogue of different modes of governance. It would be productive to think beyond the oversimplified understandings of governance modes and embrace flexible and different hybrids of governance modes to be more responsive, effective, efficient, and equitable.

Keywords: COVID-19, hybrid governance, market governance, network governance, South Korea

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INTRODUCTION

The pandemic responses of South Korea have been held up as the role model across the world. The defining feature is its proportionate and effective response that has not called for harsh lockdown measures similar to those which we have seen in decentralized federalist Western democracies such as Germany and Switzerland. What kind of institutions enables such an achievement? A survey of the pandemic policy demonstrates the value of strong public institutions (1), especially when long-term investment, trust toward the government (2), and fast adaptation of responses (3) are present. We agree with these assessments and distilled these observations into three governance principles that underpin the pandemic policies: resilience, efficiency, and transparency. More importantly, we move away from painting the government as the hero that took decisive actions or a villain that could exert authority over the culturally obedient citizens (4).

In this article, the story is justifiably complicated through the lens of the whole-of-society approach, whereby the interactions across the public, private, and civil society sectors should be the focus [(5), p. 4]. Their interactions have not been explicitly outlined in the nascent literature on the governance of COVID-19. This study draws the data from public source data and articles from March 1 to September 30, 2020, to discuss the early governance responses for COVID-19 in South Korea. We outline three governance enablers that may explain the successful containment

of the disease in the early stage of the outbreak. The literature has acknowledged the shift from government to governance (6). It makes explicit governance modes, namely, hierarchy, market, and network (7). Hierarchy is replaced by the network (8). Hierarchy can also complement the network (9). Instead of the individual governance modes, most recent analyses focus on the interactions between the modes under the frameworks of hybrids governance (10) and meta-governance (11). The former has embraced principles of complexity and evolution while the latter was further developed into concrete typology around the relationship between the meta-governor and network governance (12). At the heart of these concepts is the understanding of balancing across governance modes. This article makes explicit how the modes complement each other in three systems that produce the responsive management of COVID-19 in South Korea to which the whole world has aspired.

CONSENSUS-BASED HIERARCHY

The modifications made to the Infectious Disease Control and Prevention Act (IDCPA) had a prominent influence in preparing South Korea for the pandemic scenarios. The IDCPA endows the government with specialized structures for distributing resources and mobilizing various actors across the whole society in the effort to fight against the spread of infectious disease (13). IDCPA was enacted to stipulate certain powers and responsibilities of the state, local governments, private sectors, medical personnel, and the public. It permits a wide range of regulations including the basic plans and projects for prevention and surveillance governance of infectious diseases, intergovernmental protocols in crisis situations, public-private response, process of the announcement and reporting on diseases, epidemiological tracing investigations, preventive measures, and compensations (14).

In the modified version, IDCPA legitimizes the central roles and functions of the Korean Centers for Disease Control and Prevention (KCDC) during the pandemic. The centralization of power in the hands of authority for responding to crises is not uncommon. After Middle East Respiratory Syndrome (MERS), the KCDC acquired greater capacity through increased staffing and training, particularly in epidemiology. Specialized divisions have been established for risk assessment, emergency operations, crisis communication, and partner coordination (15, 16). The KCDC is authorized to coordinate with the newly established subnational centers for epidemic countermeasures across provincial and municipal governments and specialized hospitals.

Silos in bureaucratic administration are likely to make coordination of crisis response inefficient when time and timing are crucial. The gravity of the crisis has triggered several administrative reforms to the management and approval systems. According to KCDC (17), the smart management system (SMS) enables mass tracing of individuals who have a positive diagnosis or have interactions with infected individuals. It is known as the COVID-19 SMS. The government conducts epidemiological tracing on a single data platform to reduce administrative inefficiencies across multiple jurisdictions. KCDC runs the contact tracing system which uses data from 28 organizations such as the National Police Agency, the Credit Finance Association, three smartphone companies, and 22 credit card companies to trace the movement of infected individuals with a processing speed of 10 min. This speedy tracing allows the KCDC to inform the local public health center, which will then notify the infected individuals.

The coordination through this SMS has been made possible due to high level of digitalization in South Korea, which has the highest number of cashless transactions in the world, as well as transportation cards that records all the destinations and are compatible with all transportation means. South Koreans also have the highest phone ownership rates in 2019 (18), and the phone companies require customers to register with their authentic identification by law. As a safety measure, only epidemic investigators at KCDC can access the location information, and once the COVID-19 outbreak is over, the personal information used for the tracing of contacts will be removed.

Neither Singapore, South Korea nor Hong Kong reveals names of the infected individuals but the combination of the information being disclosed, together with other information in the public domain, may potentially allow the speculation of identification. There have been few accounts of illegal doxing in early February, where identities of the infected individuals and personal data (gathered from public and private sources) have been disclosed on websites, social media, and public forums without their consent (19). On March 15, the government has announced a new guideline for privacy protection and banned the release of any specific information that might be used to identify infected individuals, but varying degree of information release was practiced among different local governments (20). At the Ministry of Land, Infrastructure, and Transportation and KCDC online briefing of SMS, public managers present at the briefing shared their cautions and promised vigilant monitoring of the system (21).

STATE-SPONSORED MARKET

Experts in the field recognize that after the MERS outbreak in 2015, there have been various changes in the infectious disease governance of South Korea. The main change is realizing that the state of medical care and quarantine are two separate affairs. The medical facility with state-of-the-art medical knowledge and technologies has failed to quarantine citizens when MERS became extremely contagious. As Lee (17) points out, there has been a significant portion of the budget spent on R&D, amounting to ∼49% of the total infectious disease governance budget. After the MERS crisis, experts realized that it was imperative to have test kits as early as possible because the development of treatments or vaccines is expected to take a significant time. Therefore, the government took an initiative in R&D with the biotech industry to develop the necessary technology for early and mass diagnosis.

In 2016, the budget on contagious diseases and quarantine systems has been expanded 134% compared to the previous year,

a jump from ∼US$59–137 million. In 2020, it has continuously risen to US$166 million, which is a 182% rise for the last 5 years (17). During 2019 and 2020, crisis management and collaborative governance infrastructure for different national, local, and international authorities have been established, enabling a nationwide epidemiological tracing platform that South Korea is using now.

The single most highlighted government response from the media was the emergency fast track approval. The public sector took a decisive measure to stop the virus using emergency fast track approval of the test kits. Experts were called to meetings with government officials and acted as a boundary spanner between the private and public sectors, communicating the support and the sense of urgency by KCDC to biotech companies that specialize in test kit development. The knowledge on the virus that KCDC has so far has been shared. A week after the meeting, KCDC approved the diagnostic test of one company. KCDC decided to rapidly inspect tests by releasing them to labs, then cross-check to evaluate their accuracy. Many more prototype tests followed, and health officials were well-armed to attack a fast-moving virus with aggressive mass testing. More than 2,301,303 people have been tested (as of September 28) (22). This, in turn, has allowed the biotech industry to share abundant samples to improve the accuracy of test kits. Korea can conduct up to 15,000–20,000 tests a day, and there was enough production to export test kits to other countries.

The government has cultivated R&D-based bioventures with strong political will and vision for the global market. They are used to fund R&D projects specifically on vaccines, preventive technologies, and test kits. Among those technologies, the government of Korea has emphasized the development of polymerase chain reaction test kits for fast, accurate, and mass testing. The total R&D projects amount to US$68 million, allocated for the prevention and diagnosis of contagious diseases in 2020 (17).

PRINCIPLE-BASED NETWORK

The national briefings and policy documents emphasized its vibrant communication with the public. The legal basis for sharing the latest available scientific information was stipulated in IDCPA, which establishes the right of the public to be informed about the latest developments and responses to outbreaks and infection control. Experts in the field have participated in sharing accurate information by actively addressing "fake news" in a variety of media platforms. Citizens also have gathered online to generate accurate information on available masks.

Central Incidence Management System for Novel Coronavirus Infection (IMS) discussed ways to eradicate fake news that groundlessly aggravates the fear and halt of public its creation at its source by sharing accurate information and ensuring fact-checking (23). Relevant government bodies and ministries such as the Korea Communications Commission; Ministry of Health and Welfare; Ministry of Culture, Sports and Tourism; and National Police Agency have decided to establish a new response system to identify fake news lacking factual grounds and promptly inform telecommunication services and Internet service providers. The Korea Communications Commission will also call emergency meetings for deliberating on fake news cases. IMS highlighted the need for all press organizations to ensure accuracy in their reporting and stressed its determination to block the spread of fake news by cooperating with telecommunication services and Internet service providers and sharing the reliable information of the government promptly. Police in South Korea are investigating a rise in false rumors about the coronavirus, including a scam in which people are asked to provide personal details in return for access to information about the spread of the disease. There will be a cyber unit of the national police agency to exclusively deal with "fake news," which leads to excessive public anxiety and causes confusion in infection control.

Media appearance of experts is frequent, in alignment with the strategy of Korea to strictly respond to fake news, which may contribute toward unnecessary anxiety and confusion in public regarding the control of COVID-19. For instance, experts from the Korean Federation of Science and Technology Societies, the National Academy of Medicine of Korea, and the National Research Council of Science & Technology appear actively on online media platforms to diffuse information and held an online forum to fact check information related to COVID-19 (24). Doctors from private hospitals who have been fighting the disease at the front line actively appear on TV and other media platforms to address the confusion of the public and misunderstandings of the disease.

After the emergence of the *Itaewon* cluster in May, several media emphasized the nature of the clubs and the super spreader, triggering homophobic responses from the public. This reflects the still conservative nature of the country and prejudices which restrict sexual minorities to be integrated into society (25). Various organizations acting for the rights of lesbian, gay, bisexual, and transgender (LGBT)+ groups have formed a queer action against COVID-19 center to work together with KCDC and Seoul Metropolitan city government to encourage those who are still not tested, criticize discriminatory media coverages, and campaign against potential exposure to domestic violence and discrimination in the workplace after being tested (26).

As we can see from the responses toward the LGBT community, the whole-of-society efforts, there is an inherent disparity of multiple actors in the society of Korea that are amplified during the crisis of COVID-19. There have been physical attacks and online harassment toward the group of infected individuals, namely, Chinese immigrants, Christians with unorthodox faiths, and LGBT people have occurred. This is in part due to the level of disclosure of personal information, which is age, gender, and workplace. This has been carefully decided by the government for the greater public good, nonetheless, some have been using these details to narrow down those who are infected on social media, putting them at risk of discrimination. Furthermore, the authority has taken punitive measures for those who do not come forward for testing despite the possibilities of infection. However, it would mean greater risk for those who are already in discriminative social contexts. Thus, the rights of vulnerable groups need to be mindfully

considered to achieve whole-of-society measures. Students and their families are affected by school closure decisions during stage 2 of the social distancing period. KCDC and local authorities have put priority tracing for potential infected cases in the school environment to make the school closures as brief as possible. While the control for the spread is imminent, authorities have expressed the understanding that prolonged school closure would place an extreme burden on students and parents in their daily lives. Emergency care support for vulnerable families, a systematic online curriculum for potential prolonged school closure, and the inclusion of the circumstances of individual schools in the decision-making process for school closures have been suggested by Congress and the government, and are being implemented (27). Public health and the freedom to lead a life as one values need to be weaved intricately with the agile, competent, and transparent government and responsible citizens (28).

DISCUSSION

The main idea in this article is to help readers and thinkers break free from the rigid framework of governance modes. The pandemic response of South Korea demonstrated that the modes overlap, and the analysis of governance as hybrids are closer to reality. These hybrids include: (1) the state that undertakes coordination based on the consensus of actor-networks, (2) the market that is repurposed with a high-risk investment of the state, and (3) the network that is steered by traditional principles of public governance. Informed by such flexible and nuanced analysis, the future debates on governance should move beyond the oversimplified division of interventionist state vs. market deregulation. An effective, efficient, and equitable pandemic response will call for the best features of the hierarchy, market, and network in different hybrid forms for achieving different purposes at different times.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

SL and RW have contributed equally to the conceptualization of the article and revised the article together. SL has drafted the article. RW added his insights. Both authors contributed to the article and approved the submitted version.

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OPINION
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Monitoring Strategies and Intervention Policies for the Enhancement and Protection of Advanced Neuroscientific Research Post COVID-19 in Italy: Preliminary Evidence

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R&D ACTIVITIES DURING AND AFTER COVID-19 PANDEMICS

The outbreak and diffusion of COVID-19 infection had remarkably affected Research & Development (R&D) activities—which includes basic and applied research—both in a short- and long-term perspective across all European (EU) states, as well as around the globe. R&D represent a critical field of work and a strategic area of investment, with an estimated return of around 428 billion dollars [∼2.5% of Gross Domestic Spending (GDP) in 2019; (1)]. Furthermore, it is well known that investment on R&D activities represent a core target in EU global development strategies. In particular, the EU Member States agreed, in the last years, to gradually increase the investments in R&D activities to the 3% of national GDP, following the so called "Barcelona target". First exploratory analyses highlighted that the impact on research activities of the outbreak was appraised as medium or severe in 85% of reached research centers or institutions, while only 2% of them reported the absence of a relevant impact on their R&D projects (2).

Concerning the economic impact, the COVID-19 pandemic has entailed several adverse effects. In general, a negative impact has been observed on different economic sectors, as marked by the increase of unemployment rates, bankruptcy, and other financial consequences. Like the other occupational sectors, productivity in biomedical, experimental, and clinical research too has been negatively affected by the outbreak and by the related pandemics management policies due to the suspension of research activities not primarily related to COVID-19, especially for basic research institutions. Indeed, as also demonstrated by a report published by the Congressional Research Service about the effects of the COVID-19 on the federal research and development company, it emerged that the mandatory implementation of specific guidelines would have led to the interruption of the research activity carried out by many laboratories due to the loss or limited access to different equipment, the inability to purchase new instruments, and the cancellation of scientific events and conferences (3). Furthermore, in addition to the experimental research field, also the clinical research and clinical practice, due to the suspension of many routine activities,

have suffered significant financial repercussions in terms of loss of wages and business, which have in turn caused several problems to the work of healthcare professionals and support personnel (4). Those phenomena produced an unprecedented crisis for global research enterprises, especially in the neuroscientific field, whose basic and clinical research activity is heavily based on first-hand data collection with test animal, test subjects or patients (5–8).

In fact, the inertia imposed by the emergency situation on neuroscience, but also neuropsychological and neurophysiological research activities, might have a too heavy price to pay in terms of social and economic aftermath. Between many, the main issues could be:

i) the delay of critical research advancements and the limited investment on developing novel and efficient applications of neuroscience and psychophysiology tools, instrumental examination, neuropsychological and neurophysiological assessment, monitoring and intervention practices to face the now renown and critical phenomenon of neuro-COVID—i.e. a clinical picture characterized by moderate-to-severe cognitive, affective, and behavioral impairments linked to COVID-19 infection (9–11);
ii) the restriction or inadequate access to clinical and research services for end-users who presents neuropsychological, neurological, and/or psychiatric symptomatology, with potentially severe consequences on their health and well-being;
iii) the direct negative effect on neuroscientific knowledge production (5) and on the development of resilience strategies for future pandemic scenarios.

The negative impact caused by the pandemics has pointed out the need to develop safe work programs, strategic rearrangement of research activities, and efficient supportive programs for economic funds (12). In particular, to limit the repercussions on scientific productivity and healthcare of the infection, some activities have been reorganized, with remote and digital tools, in most institutions and centers (13, 14). It was also asked to the scientific community to identify and implement evidence-based policies that could promote the development of new, resilient, and shared cultural practices, which involve the combination of effective remote work and on-site activities even in the neuroscientific field. Standardized and shared policies are necessary in order to improve activity and make neuroscience, neuropsychology and neurophysiology research and practice in the laboratories overcome the crisis, to capitalize present experience, and to be prepared to face potential future challenges while, at the same time, assuring public health for all the actors involved.

In line with this need, many research groups have begun to share consensus guidelines for the management of neuroscientific data collection in the pandemic period. Bikson et al. (15) proposed consensus guidelines for TMS/tES clinical services and research through the COVID-19 pandemic. In a similar work, Campanella et al. (6) reported the outcomes of a survey on the impact of COVID-19 on the use of electroencephalography (EEG) in clinical practice and research in several countries (including some EU countries such as Italy, Germany, Belgium and Czech Republic). The authors have also presented the recommendations of an international panel of experts for the safe application of EEG during and after this pandemic. Even if based on a limited number of participants and restricted to a peculiar area–i.e., electrophysiology–the study is insightful and carries within itself some precious information about situational know-how and strategies, which might reduce risks for COVID-19 spread. Among the others: a rigid check for COVID-19 symptomatology before inclusion in studies and research activities; respect of sufficient social distance and favoring of one-to-one contact, primarily between the technician and the patient, in data collection; the use of different rooms for data collection; disinfection between each recording. The authors have also suggested an update of common practices to allow safe EEG recordings in both research and clinical settings. In parallel, Sozzi et al. (7) proposed potential solutions for conducting neuropsychological assessment and neuropsychological rehabilitation with patients showing alterations of cognitive functions even during emergency situations. Furthermore, a roadmap for conducting neuroscience research in the COVID-19 era, together with the recommendations from the Society of Neuroscience in Anesthesiology and Critical Care (SNACC) Research Committee was recently published (8).

AN APPLIED EXAMPLE: THE MIRNA PROJECT

Aims and Project Structure

Building on such premises and on the state of the art on investment toward safe reprise of R&D activities, we will now briefly introduce an illustrative recent project that involves three main partners—the Catholic University of the Sacred Heart, the Foundation "Policlinico A. Gemelli", and the University of Genoa—to discuss a few critical points concerning the progress of neuroscientific research in Italy during the pandemics.

The project (entitled "*Monitoring tools and intervention policies for the enhancement and protection of advanced neuroscientific research post COVID-19*"–MIRNA) was devised to evaluate and highlight the impact that the COVID-19 had on the management of basic and clinical research activities conducted by Italian laboratories for neuroscience, neurophysiology, and clinical neuropsychology during the pandemic emergency and post-emergency phases. By mapping the state of the art of such laboratories and by collecting data through a national survey, the main purposes of the present study were: (i) to define primary activities of research units and laboratories operating in the field of basic, clinical and applied neuroscience, neurophysiology and neuropsychology in Italy; (ii) to qualify and quantify critical issues resulting from the COVID-19 in those settings; (iii) to highlight the strategies used to address or mitigate those unprecedented challenges.

Firstly, to pursue such goals, Italian institutions operating within the neurophysiological, neuropsychological, and neuroscientific research fields were initially mapped in order to collect a sample as representative as possible. The systematic

mapping of Italian neuroscientific, neurophysiological, and neuropsychological research facilities leads to the identification of 254 laboratories/units, which have been categorized based on location, primary research field, and category of institution.

Secondly, the outcome of such mapping, besides being used for outlining the state of the art of neuroscientific, neurophysiological and neuropsychological research institutions in Italy, has been used to define a reference population of respondents for a survey designed to identify critical issues faced by research managers and laboratory directors during the pandemic emergency and the post-emergency period and to investigate the effect of the pandemic outbreak and of related management policies on research activity and productivity, as well as the strategies and policies that have been implemented to face such issues and foster reprise of R&D activity. The survey was implemented on Qualtrics XM platform (Qualtrics LLC, Provo, UT, USA) and divided in five different parts: (i) consensus and introduction; (ii) general data on the institution and the respondent and pre-pandemic phase; (iii) research activity during Phase 1—first lockdown (from February to May 2020); (iv) research activity during Phase 2—second lockdown (October 2020 to May 2021); and (v) summary evaluations of the pandemic period (overall considerations regarding both Phase 1 and Phase 2).

Mapping and Survey Evidence: Some First Remarks

The preliminary mapping revealed clear disparities in the regional distribution of laboratories/units involved in research and/or clinical activities in the fields of neuroscience, neurophysiology or neuropsychology (see **Figure 1**), with about a half of the units located in Lombardy, Lazio or Tuscany.

The whole sample of mapped institutions was constituted almost equally by purely research (45%) and mixed clinical and research (44%) units, while the institutions with a primarily clinical mission covered a smaller part of the sample (8%).

The analysis of respondents across the national territory highlighted a response rate equal to 39% (55 out of 142 laboratories/units have completed in the survey) in northern Italy, 16% (11 out of 70 laboratories/units have completed in the survey) in central Italy, and 23% (10 out of 43 laboratories/units have completed in the survey) in southern Italy.

Focusing on the sample of survey respondents, which almost equally represented primarily healthcare/clinical research professionals (53%) and primarily basic research professionals (47%), it is relevant to note that just about one fourth of them reported the existence of emergency management guidelines to help strategic decision-making and inform the rearrangement of lab/unit activities in case of a disease outbreak, a percentage that has grown up to 94% after the COVID-19 emergency. This led to a closure rate equal to 92% for purely research laboratories/units during Phase 1, compared to 52% of mixed clinical and research units and 60 % of primarily clinical units. A similar, though more restrained, scenario was observed even in Phase 2, with 44% of purely research units still closed, vs. 5% of mixed units and 10% or primarily clinical ones.

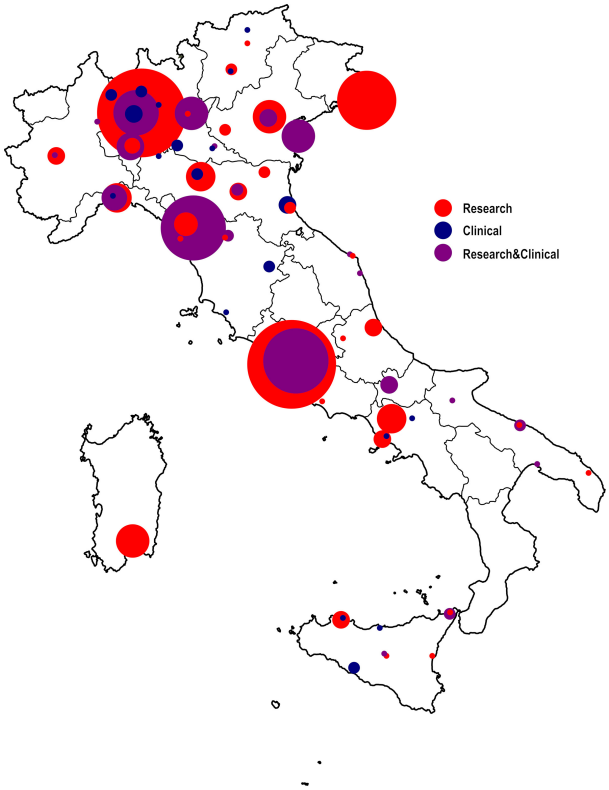

FIGURE 1 | Mapping of Italian neuroscientific, neurophysiological, and neuropsychological research facilities. Laboratories and units have been clustered according to their main working activities: in red the laboratories that carry out research activities only, in blue the centers that primarily conduct clinical activities, in violet the centers that deal with both research and clinical activities. The width of the circles mirrors the number of laboratories/units in the reference geographical territory, for each clustered primary working activity (i.e., research, clinical, both).

Again, another impactful observation emerging from the survey is that, while the number of submitted paper during phase 1 and 2 was almost comparable to a previous reference period (year 2019), the investigated research and clinical institutions reported a remarkable decrease of 23% for planned and submitted projects, a percentage that reaches −40% in mixed clinical-research units. We suggest that such loss of research projects in the field of basic, clinical and applied neurosciences, of their potential outcomes in terms of novel theoretical models and technological/methodological progresses, as well as of potential by-side discoveries might show its effects in the next few years.

CONCLUSIONS

We think that the pandemic emergency that we have had to face provides, at least, the unique opportunity to reflect on the strategic value of clear, efficient and lean organizational and management guidelines, as well as of both effective vertical communication between institutions and its components and horizontal communication to share evidence-based practices

between institutions. Projects like the one briefly introduced here will provide valuable food for thought concerning the development of standardized and shared practices necessary to restore pre-epidemic activities and planning, in order to ensure that R&D overcomes this crisis and potential future challenges, while also protecting the public health and all actors involved in the strategic research field of basic, clinical and applied neurosciences. Indeed, to define guidelines and new best practices for an efficient and sustainable management of these necessary activities in the short and long term is a current critical challenge, and might help containing the cost of their interruption on healthcare for the population and on individual/social well-being.

AUTHOR CONTRIBUTIONS

MBa, DC, LA, and GF wrote the first draft of the manuscript. All the authors contributed to the manuscript final writing and revision. All the authors read and approved the submitted version.

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What a Pandemic Has Taught Us About the Potential for Innovation in Rural Health: Commencing an Ethnography in Canada, the United States, Sweden, and Australia

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The COVID-19 pandemic coincided with a multi-national federally funded research project examining the potential for health and care services in small rural areas to identify and implement innovations in service delivery. The project has a strong focus on electronic health (eHealth) but covers other areas of innovation as well. The project has been designed as an ethnography to prelude a realist evaluation, asking the question *under what conditions can local health and care services take responsibility for designing and implementing new service models that meet local needs?* The project had already engaged with several health care practitioners and research students based in Canada, Sweden, Australia, and the United States. Our attention is particularly on rural communities with fewer than 5,000 residents and which are relatively isolated from larger service centres. Between March and September 2020, the project team undertook ethnographic and auto-ethnographic research in their own communities to investigate what the service model responses to the pandemic were, and the extent to which local service managers were able to customize their responses to suit the needs of their communities. An initial program theory drawn from the extant literature suggested that "successful" response to the pandemic would depend on a level of local autonomy, "absorptive capacity,*" strong service-community connections, an "anti-fragile†" approach to implementing change, and a realistic recognition of the historical barriers to implementing eHealth and other innovations in these types of rural communities. The field research in 2020 has refined the theory by focusing even more attention on absorptive capacity and community connections, and by suggesting that some level of ignorance of the barriers to innovation may be beneficial. The research also emphasized the role and power of external actors to the community which had not been well-explored in the literature. This paper will summarize both what the field research revealed about the capacity to respond well to the COVID-19 challenge and highlight the gaps in innovative strategies at a managerial level required for rapid response to system stress.

*Absorptive Capacity is defined as the ability of an organization (community, clinic, hospital) to adapt to change. Organizations with flexible capacity can incorporate change in a productive fashion, while those with rigid capacity take longer to adapt, and may do so inappropriately.

†Antifragility is defined as an entities' ability to gain stability through stress. Biological examples include building muscle through consistent use, and bones becoming stronger through subtle stress. Antifragility has been used as a guiding principle in programme implementation in the past.

Keywords: innovation, rural, health systems, virtual care, COVID-19

INTRODUCTION

The aim of this research was to describe how health and care services in small rural areas in Australia, Sweden, Canada, and the United States of America (USA) engaged with their communities in the early part (March-October 2020) of the COVID-19 pandemic. Throughout the field research, two broad frameworks were developed—one focusing on *what* health and care services (and other actors) were doing, and one on *how* services were able to respond well to the challenges the pandemic presented. This paper focuses on "success stories," hoping to provide positive inspiration for communities of this type. While the focus on success could obscure the full perspective of how rural health systems responded to the COVID-19 pandemic, the motivation to focus on these successes is to disseminate knowledge about what works where and for whom in a sparsely researched area. There were, of course, also examples of responses that the research team perceived to be poor or insufficient, and assessing these are part of our future directions.

The geographical context for the research was central to its undertaking. Our research interest has long been in understanding how health services operate in small rural settings, where service sustainability is challenged by relatively small population sizes (the largest towns within a functional service area having fewer than 5,000–7,000 inhabitants) and intermediate distances to larger service centres (1, 2). By intermediate distances we mean that larger centres are accessible by road without necessitating (although they often do involve) overnight stays, but not daily. These areas typically have a high reliance on locally based primary health care (PHC) facilities with small permanent staff numbers (often restricted to physicians and nurses) and ancillary services (allied health, dental health, mental health) provided by visiting or locumpractitioners. Service delivery also features frequent demands for users to travel within and out of the area for even relatively minor treatments (including diagnostic imaging and bloodwork) (3, 4). The incidence rates of COVID-19 can be found in **Figure 1** below (5). USA has the highest incidence of COVID-19 (measured in daily cases per 1 million people). Sweden follows, with Canada and Australia third and fourth, respectively. **Figure 1** clearly displays the spikes in daily case loads associated with waves of COVID-19 infection. The ethnography completed in this study occurred during the summer of 2020, which coincides with the second wave of COVID-19 infection world-wide. Of particular note is the recent change in case load within Australia and Sweden. Differing COVID-19 management strategies led to Australia having relatively low case numbers for the better part of 2 years. Sweden meanwhile adopted a herd immunity tactic, which led to case numbers per 1M people rivaling that of the USA. In the fourth wave of the fall of 2021 however, Sweden case numbers dipped below Australia's for the first time since the beginning of the pandemic.

The ability for local health and care services to act somewhat autonomously in responding to health risk events like the pandemic should be seen as a critical part of socially responsible and community-based care paradigms (6–8). These paradigms emphasize the need for services to understand the communities in which they operate and to tailor what they do to the needs of those communities (1). Given the diversity of rural communities (9), this means that services in even relatively proximate communities could and should operate differently to one another. There is of course a tension between allowing sufficient local autonomy to develop community responsive service models and maintaining regional, provincial, or national standards (10), and part of the value of this research is contributing to understanding and potentially resolving that tension.

While many health risk events are largely unexpected and require rapid response, the COVID-19 pandemic has presented some specific challenges (11). It has been a protracted event, with health service delivery substantially affected for over a year at the time of writing. It has been a geographically widespread event, with global impact. Further, it has been an event which has directly impacted health service delivery, causing changes to how and where and what services are delivered (12). Our study addresses the gap in knowledge with regards to rural health system innovation in the face of an unprecedented stressor such as COVID-19. This ethnography sought to document—in real time—the responses to COVID-19 and codify them for future reference and dissemination as policy reforms for rural health systems and services. Creating a body of literature for rural practitioners, especially with regards to what worked for other communities in diverse contexts both geographically and system-wise, could strengthen rural health systems as the COVID-19 pandemic marches on.

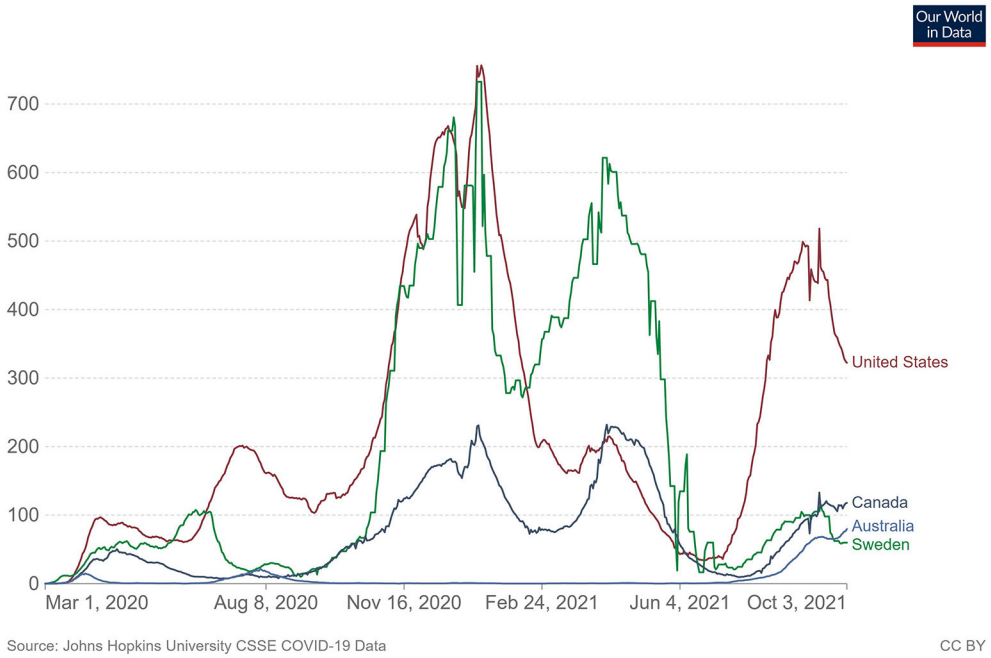

FIGURE 1 | Daily new confirmed COVID-19 cases per million people Shown is the rolling 7-day average. The number of confirmed cases is lower than the number of actual cases; the main reason for that is limited testing. Source: Johns Hopkins University CSSE COVID-19 data.

METHODS

The research was conducted from a service user perspective, involving ethnographic and observation-based methods employed by members of the research team who were residents of or visiting communities at the time. While researchers were asked to position themselves as if they were a service user, it is important to note that all members of the team were in some way associated with the health and care sector (although not necessarily in the communities where they conducted research)—as practitioners, students or researchers. The team employed both a recursive (13) and discursive research approach, with regular sharing of ideas and insights between team members in the same country and between countries guiding what was done next and the development of frameworks for data capture and analysis.

The purpose of those quick village vignettes was to provide a glance at what health and care services are available and what are restrictions had been implemented due to the COVID-19 pandemic. We selected several villages from regions in Australia, Canada, Sweden and the USA for comparison and inclusion in the dataset, each following a similar methodology (14). The inclusion criteria of these sites was largely open-ended, with consensus from the group part of the process in determining if a site was appropriately rural. Proximity to these sites by our group also figured into their selection, as the logistics of conducting an ethnography in the midst of the second wave necessitated streamlining various factors such as the ability to assess community response and familiarity with systems. The resultant vignettes from selected villages offer a contemporary snapshot of the efforts service providers made within the context of broader shifts in health and care delivery.

The overall methodology for the village vignettes was as follows: we briefly described selected case sites in terms of their eHealth development and institutional arrangements for local health and care systems *prior* to the pandemic. Next, we briefly described the jurisdictional (national and provincial) eHealth responses to the pandemic which are particularly relevant to small rural health and care systems in the context of the macro factors (demography, economy, accessibility) already influencing design and redesign of these systems. Following, we provided examples of how health and care systems have been affected by the pandemic in specific communities, looking particularly for "extreme" cases which show either innovative engagement in new ways of working at the local level, or substantial challenges faced. Lastly, we use the rural eHealth literature, the experiences of the case sites, and our own experience as health and care professionals, researchers, and educators during this period to identify issues arising from the rapid expansion process which local systems need to consider when planning eHealth beyond the pandemic.

Building from the above, we developed a methodology of what we did for each village, with the recognition that there will necessarily be some variation given local contexts. When conducting our investigations, we were guided by

an impact domain framework which sought to holistically evaluate the COVID-19 response. This framework includes patient risk (continuity of care, inclusive care, accessibility), service design and innovation (empowering local service managers and communities, service integration), workforce (recruitment, retention, education and training), the technology itself (compatibility, usability), and stakeholder engagement (government agencies, private health and care providers, universities). The framework identifies how the rapid expansion of eHealth services might provide benefits and mitigate negative impacts in these domains, offering suggestions as to how small rural systems might respond to the challenges and use this opportunity to improve the provision of health and care services in what might be considered marginal environments. This framework prescribed the themes which guided our ethnography at these various sites (15, 16).

For each village, we followed a similar set of guidelines where we examine health and care services across a range of factors, developing a quick "picture" of what might be available to residents. This methodology is in essence a remote access version of a village observation protocol, where we take a glance at villages from the outside and look for indicators of activities such as migration, employment, or social connection. Here we are looking at the range of health care services in a village, what was present before the current pandemic, and how these may have shifted in the recent months. With our impact domains of patient risk, service design and innovation, workforce, and stakeholder engagement in mind, each village facet was examined through the following methodology:

Service	Elements	Sources
Context	Distance to larger center Distance to hospital Number of physicians Population & pop. change Other relevant context	Websites & Google Maps Statistical Agency Social media
Physician	Availability Booking (phone, online)	Websites/Social media Clinic phone messages
Hospital	Emergency Services Walk-In Clinics? Testing & blood clinics Routine Clinics	Websites Phone messages
Public Health	Presence of Public Health Unit Information on COVID-19 Updates & Relevance	Social media Websites
Mental Health	Walk-In/Telephone Services Counselors & Psychologists	Social media Websites Listing on other sites
Municipal Services	Services available/limited Face-to-face, telephone Online systems Updated information	Website Phone message Social media
Social/Community Services	Home-care services	Websites
Other Care Services	Long-term care facilities Physiotherapy Dental, orthodontics, denture	Websites Phone messages Social media

Basis for Comparison

While our research was conducted in broadly similar geographic contexts in the four countries, the selection of those countries and the specific case sites within them was largely opportunistic, being where members of the research team were located or had regular access. Given the guiding methodology was under an ethnographic paradigm, it bares examining the bases for comparison encompassing both similarities and differences.

At a political level, Sweden's (at least the parts of Sweden where this research was conducted) health care system is almost entirely publicly funded and administered (17). There are private practitioners (mostly locum service providers) but they are contracted to the public system. Australia and Canada have similar public-private service models involving fee for service reimbursements from public and private health insurance providers (18, 19), and a mix of public and private services. The USA largely relies on private provision of health care, with minimal public insurance and government-operated services (20).

All countries have highly regulated health sectors, with national systems for approving pharmaceuticals and treatment methods, and strong medico-legal systems. However, all countries also have complex health system structures particularly in rural areas (21). The complexity arises from the interactions between public and private sector actors, and even more from the division of responsibilities between different levels of government (national, provincial, and local). This is perhaps most extreme in Sweden where local government has direct responsibility for the provision of aged care, home-based care, health services in (junior) schools and other community-based services.

Local government does not have such responsibilities in Canada (22) or Australia, but there is a division between provincial and national government responsibilities with provinces managing (among other things) hospitals and emergency services, and national government managing medical workforces, health insurance and regulatory frameworks. Provincial and even local governments in the USA have legislative power to intervene in health service administration and delivery and do so in different ways depending on political orientations. The configuration of health care services can differ dramatically even in relatively proximate locations in the USA. In all countries, there are regular debates between levels of government about health care funding and responsibilities and concerns about lack of coordination between levels of government (and government and private providers) that lead to duplication of services and substantial service gaps (22, 23).

In Australia and Canada, towns at the larger end of our size spectrum are likely to have both a general practice/ family practice clinic and a hospital with limited functionality [aged care, rehabilitation, triage (24)]. Swedish rural sites provide care through a "cottage hospital" (*sjukstuga*—plural *sjukstugor)*. Occasionally there may be separate facilities for dental health (or physiotherapy or mental health), but usually non-GP services operate out of the hospital and are delivered part-time. Smaller towns may have a general practice clinic operating part-time. There are privately operated pharmacies in larger towns. In small

rural Australia and Canada, accessing health care almost always involves visiting the hospital or the clinic. Rural hospitals are always at risk of closure and reduction of services (25).

The United States has a model of care different from Sweden, Australia, and Canada (26). This private model of care means that most services which are subsidized by taxpayers in our other three countries require out of pocket expense if an individual in the United States does not have private health insurance. In the north-eastern United States, where our vignettes were based, there is a large telehealth service which connects rural physicians with specialists at a larger urban hospital. Having very good existing technological infrastructure aided rural Americans in New England in their transition to online models of care at the onset of the COVID-19 pandemic.

RESULTS

Access to service is assessed through reporting of how these rural villages and towns handled service provision during the onset of COVID-19. Additionally, access was assessed by evaluating information such as resource availability and mechanism of delivery. They were recorded by researchers who lived and worked in these communities.

Canada

The Canadian rural response to COVID-19 was measured in two separate contexts from both a quantitative perspective (to ascertain demographics) and a qualitative perspective (to analyze actual practices implemented to expanding and changing care). The province of Ontario and the province of Nova Scotia were chosen as suitable candidates to draw sites from, mostly due to the proximity of our research group to these provinces, and the access to existing contacts and circles already established in previous research projects.

It is worth noting that as of the time of writing this paper, Nova Scotia and Ontario have had much different experiences in managing the COVID-19 pandemic. Nova Scotia has seen great success'bubbling' with neighbor provinces in the Canadian Maritimes. Besides the odd outbreak over the summer of 2020, trends of COVID-19 spread in Nova Scotia have been extremely small. Ontario however began it's third wave of COVID-19 spread in early March 2021 and entered a 28-day provincial wide lockdown on April 3rd 2021 to flatten the curve of COVID-19 transmission. Acknowledging this is important, because much of the services in Nova Scotia could be provided mirroring their service prior to COVID-19 disruption.

With regards to service provision, both provinces responded to the COVID-19 pandemic with changes to service protocols, but Ontario was far more drastic and longer-lasting in their approaches. For example, In Nova Scotia cancer care was continued, while in Ontario, some treatments and surgeries were delayed. Many elective surgeries were delayed in Nova Scotia at the outset of the pandemic, but as they successfully flattened the curve treatments which had been postponed were rescheduled promptly. Ontario had to postpone much of their elective surgeries, and as Ontario enters a third wave, many services which had been postponed over a year prior still have not seen a return to their implementation prior to the pandemic.

Further, Nova Scotia has one web domain with all health centers throughout the province included, with updated information during COVID-19. While Nova Scotia had one web domain for most major hospitals and clinics, this domain was *not* linked to most family physician offices. Family doctor offices provided links to governmental resources for patients, but rarely did they update their own websites. Ontario has individual websites per health centre which are updated at the discretion of that health centre, meaning some haven't been updated in years. This has made getting service in rural communities difficult, and there is no clear avenue to see who the appropriate person is to approach about getting information regarding up-to-date information for health centers. Centralizing health center informational streams on one domain expediates the process of informational exchange, and allowed for current displays of protocols, progress, and changes to service provision. The response from larger urban health centers were generally the same in both Ontario and Nova Scotia. No visitors, redirection of patients to other services. Non-urgent medical tests were pushed. These include screenings and medical imaging. Many centres stopped taking drop-ins but were still seeing appointments.

One very encouraging practice which came out of Ontario was the County Virtual Triage Assessment Center (CVTAC) was developed in an effort to redirect patients using the emergency department/hospital for things that can be provided by a family practitioner, such as prescription refills. The goal of the implementation of CVTAC was to strengthen access to primary care, as per the county's webpage. It's goal was to reduce the demand on the emergency department, and its prolonged implementation can only be beneficial in combatting emergency department overcrowding into the future post COVID-19 pandemic. Without the CVTAC, the primary care which was available in rural Ontario was difficult to access before the pandemic and became near impossible during it. Unfortunately, the funding which support CVTAC is tied to COVID-19, and will likely disappear once vaccinations begin to ramp up. Technology and innovative strategies like CVTAC need clear funding sources moving forward, as creating an inherent clause in their implementation to roll them back post COVID-19 is damaging to the overall rural health system they were introduced into.

Group services, much as in Sweden and Australia, saw a pause in most communities, but there were some progressive community groups which relied on volunteers to perform group activities which existed before the pandemic, and create novel activities during the pandemic to combat social isolation. These community volunteer groups were usually (but not always) faith based and did not have external funding. There was minimal guidance or recruitment for official group activities run by either health authorities or public health offices in rural Ontario and Nova Scotia.

While Nova Scotia has a smaller population, the concept of having one health information source (one website) ensures that the entire province is on the same page, in terms of response to COVID-19. It also ensures that there is up to date and clear

communication from all health centres, as they all fall on the same website. This also lessens the confusion as to what is a reliable source. While health centers benefitted from uniform messaging across sites, individual physician offices or webpages did not update their information regularly. Most sites were out of date, and those which were current did not provide any specific information for their context, and instead referred patients to the larger Nova Scotia web page for health centers.

In Ontario each health centre has their own individual website (much like each individual family physician office in rural Nova Scotia). This was a problem in Ontario as health center websites are more prominent and were consulted more frequently for information. Many of the websites being looked at in the vignettes, were dated and unreliable, with no current information on COVID-19. Many had more reliable and up to date social media accounts (Facebook, Instagram and Twitter). There were also instances of social media accounts for the health centres that were run by members of the public, not associated professionally with the health centre. While most of these accounts were run in good faith, there is of course the possibility that these accounts could post information to craft a narrative of disinformation, which existed during the pandemic if not monitored by an official source. This makes for a more difficult search to find information, leading people to call or go to centres to find out more information. Or avoid centres even if they are sick, due to the unknown measure put in place to protect those without symptoms of COVID-19.

USA

American COVID-19 response was measured using the same metrics as the Canadian context. Vignettes were chosen from north-eastern United States, in the Vermont and New Hampshire areas. Again, like the Canadian, Australian, and Swedish contexts, these communities were chosen because of their proximity to our research cluster. These communities are likely not a good representation of the average community in the United States, as their median income is much higher than other states. Their affluence may be part of the reason the infrastructure and services available to them are better, relevant to their Swedish, Canadian, and Australian counterparts. The private nature of the American healthcare system also means these households can dedicate more of their income to their health and will probably be able to access services which many rural communities cannot.

All the vignette sites had access to family physicians, while only one provided the access through a regional hospital. Most sites increased their service provision during COVID-19 through a hybrid approach of telehealth and online services. There was already an existing service which connected rural physicians (and by extension, their patients) to a dumber of specialists at a larger level 1 trauma center in New England. This likely smoothened the process of change of service protocols, as much of the precedent and comfort of working through eHealth existed in the area.

Communication at the American vignette sites was good, with most of the vignettes having up to date websites regarding COVID-19 protocols. Additionally, most had a way to notify the public when protocol changes, with social media accounts run in conjunction with clinics and health centers in the area. When compared to Ontario and Nova Scotia, the New England sites were not all on one domain like the Nova Scotian centers, but they weren't quite as diverse as the Ontario sites. All sites seemed to be run with some leadership and direction, but this could not be confirmed from the information provided. Commonalities such as phrasing and links to other resources however point to some co-ordination in messaging and keeping the information current was common to all vignettes chosen. Outside of that, much of the broad responses to the pandemic were the same in the United States as they were in Canada, Australia, and Sweden—pushed elective surgeries, physical distancing, and limited visitation.

Interestingly, much of the response in the New England hospitals seemed to be on a consultation basis, with numerous clinics and hospitals stepping up their public health footprint during the COVID-19 pandemic. They offered information broadly on how to avoid the virus, but one site also offered information which would be unique to that site's context—namely, how to reopen small business again safely and successfully, following government mandates and health outlines. This tailoring to community concerns is a positive outcome seen in the other countries analyzed, where at their best rural health centers become resources for things other than strictly health guidelines. Becoming trusted centers of information for things such as small business protocols was a positive reinforcement of the beneficial standing most of these centers have in their communities.

Another positive of the United States rural COVID-19 response was the focus on mental health. Like other health services, much of the mental health programming was transitioned into a telehealth or eHealth medium at the onset of the COVID-19 pandemic. There was however a conscious effort, as evidenced by resources online and through social media content, in reaching out to patients regarding their mental health and ensuring that they knew their options. In comparison with the rural Canadian sites, the focus on mental health in the United States was coordinated across organizations and health centers and prioritized by health authorities.

Australia

In Australia, the most striking phenomena was the contrast in responses from primary care facilities that were quite proximate to one another, and in one case even had clinics in the same town. In one case, all that was offered was a handwritten sign on the clinic door saying to call for an appointment or attend during reduced hours. No website or social media presence, no further information. Once you called the number or presented in-person, you got the treatment you were looking for—renewing a prescription or a similar service—but it did seem like the clinic was somewhat divorced from the community. In contrast, we saw other clinics who seemed less narrowly concerned about their own business (making sure they had access to their patients) and more concerned about their role in the community. They became the main sources of credible local information about COVID-19 and about how you could navigate the health and care system while the pandemic restrictions were in place. Like in the north-eastern united states, this was a positive

outcome of COVID-19 response. Improving their visibility in the community meant having clear signs at the clinic, on community noticeboards, on their own websites and social media, and on other websites and social media that the community were likely to use.

We also saw some of these clinics expand their scope of practice, or at least engage in different activities or do them in different ways to what they had done previously. The "public health consultant" role was a clear one—in the past this may have been a passive role involving brochures and posters at the clinic, but now was a service you could access by calling the clinic and getting advice about community-based services and their operations during COVID-19. There were also cases of local services delivering public health messages in novel ways (through musical performance, for example) which increased the reach of information. This was particularly important for mental health related issues.

There were other forced changes that had the potential to be handled better. One was the interruption of group-based treatments. Groups obviously couldn't meet face to face, but the only alternatives we saw were instructions to call a certain number for a one-to-one consultation if you felt you needed it. Similarly, patient transport services were interrupted, and people who did have to travel for advanced care either went without that care or had to find an alternative with not much help to do that. We saw something similar with respite care suddenly being inaccessible and obviously creating problems for patients and their caretakers.

Aspects of navigation through the system did seem to be well-addressed. A particular example is the apparent streamlining of processes between the clinic and the pharmacy. In the past, the patient needed to take the prescription physically from the clinic to the pharmacy, and then the pharmacist might have to check with the physician and so on. But at least in a couple of cases we saw the clinic communicate directly with the pharmacist, so everything was ready for the patient when you arrived at the pharmacy. Again, this worked well for people who were well known by the clinic and the pharmacist but may not have been so functional for more marginalized members of the community and was not standard practice across all clinics. We also saw an increase in whole-of-family services, the most notable being scheduling influenza vaccines for the whole family at once rather than one person at a time. Often, this was done on a "drive-through" basis with clinic car parks and public spaces becoming temporary consulting rooms.

In general, we saw that clinics could and did do a lot to ensure that their own services to their own users were not just maintained, but even enhanced by things like teleconsultations and streamlined referral processes. We saw that clinics could and did assume roles as community leaders in the provision of local and general information about the pandemic and how to access care during the pandemic. We saw more use of telehealth rather than eHealth, in the sense that virtual consultations were by telephone and audio only rather than by videoconference.

In summary, the evidence we had was that primary care services which were well-connected with the community and who saw their responsibilities as extending beyond providing their normal fee-for-service activities were able to exercise leadership and implement new ways of doing things. This not only minimized disruption but enhanced quality of care and efficiency of care provision within a short time frame. Further research is needed to understand how vulnerable or marginalized populations were supported, and to see how local services managed their relationships with provincial health departments, distant specialists, and other external actors. Our impression from the limited exposure we had to these latter was that they were simply waiting for things to "return to normal" rather than investing too much in adapting their services during the pandemic.

Sweden

Parts of rural Sweden is known for its history of health service innovation, particularly in the use of eHealth. There's documentation of eHealth developments over at least the last 30 years (27), and in recent times the region has received academic attention for novel methods of delivery primary care services in communities without health services (28) and for local engagement in medical education (29). Some of this innovation has come "top down" from the provincial health department, but quite a lot of it has come "bottom up" from local health services, particularly in the municipality of Storuman, where a physician established a "Centre for Rural Medicine" some 10 years ago (30). In some ways, then, services in this region were reasonably well set up to deal with the challenges presented by the pandemic. Teleconsulting was already common, including teleconsulting for emergency and primary care. Most health services already had pretty high-quality video-conferencing facilities. Electronic prescriptions, electronic referrals (and teleconsulting with distant specialists), digital platforms for booking appointments, remote imaging (ultrasounds, dermatology etc) and other "doctor at a distance" techniques were widely used and quite well-understood by service providers and users.

Health and care services in this region have been used to operating in crisis mode and this, along with the relatively late arrival of the COVID-19 virus in the rural communities here (very few cases until October 2020) perhaps contributed to a complacency among providers and users. Adapting to recommendations to limit physical contact was quite easy since the sorts of techniques to facilitate that were already widely used. Nevertheless, we did see some of these practices become more entrenched in locations which had not used them so much previously, and more support came from provincial and national health authorities for embedding these practices in primary care services. One of our research team noted that stakeholders were somewhat surprised at how quickly health authorities were able to change procurement procedures and other administrative aspects that had contributed to a reputation of a slow-moving public health and care system. Those central innovations then allowed some local services to enter partnerships with technology providers and trial models of service delivery (including virtual clinics with the physicians located in other parts of Europe) that might have taken much longer to put in place prior to the pandemic.

Generally, though, what we saw at the local level was not so much innovation as extension of practices that were already being established. The process of moving from heavy reliance on expensive locums to provide in-person services to increasing use of digitally mediated services as a COVID-19 response to local workforce shortages had already begun but was accelerated by the pandemic. While this meant that local services could continue to mediate "good and close care" (in terms of limiting the need for patients to travel) as required by the Swedish national policy, it also meant that the physical distance between communities and care providers increased.

There were some signs of breaking down of barriers between municipal and provincial services. In one case at least, provincial staff were redeployed to municipal-run aged care facilities rather than the municipality being forced to acquire increased debt to bring in "emergency" staff from outside the region. This did mean that other parts of the system were left unstaffed, or staffed by unqualified personnel. This was particularly difficult in municipalities which had previously invested heavily in supporting in-home aged care through frequent home visits by district nurses and others. Nevertheless, it demonstrated that cooperation between levels of government was possible, and that such cooperation could be initiated locally.

DISCUSSION

The HOW Framework

Local autonomy in rural health can be compromised by structural factors such as workforce turnover, limited funding, tensions between levels of government, medico-legal concerns, lack of access to information and knowledge, latent inertia and risk aversion. In highly regulated systems it may be difficult for services to act locally to implement initiatives that have not been centrally mandated. This may particularly be the case in rural areas where services are often fragile because of difficulties in recruiting and retaining professional staff, insecure funding and a tendence by regulators to more closely monitor policy compliance among services they rarely physically visit. Discouraging local action may increase in times of crisis as regulatory agencies implement centrally managed crisis management plans.

There is evidence, however, of locally driven and novel initiatives in rural health in each of the four countries (11, 31). The CVTAC in Canada, the adaption of health promotion responsibility and material in all four countries, and the technological adjustments to prescriptions and services by pharmacies and rural medical centres are three examples from our field research which point to an ability of rural communities to innovate in the face of system stress. A number of telehealth initiatives, and mechanisms for cooperation between local and provincial government have all emerged from within services based in rural areas. In all four countries, changes in rural health care systems usually result from pilot studies or limited trials which expose local services to "doing things differently" from neighboring services and building capacity as leaders and participants in innovation and reform, but with the tension of change being so high, innovation and reform become the norm of operating in rural communities.

There is a growing literature on innovation in rural health which has a focus on locally driven initiatives (32–34). The literature mostly focuses on the innovations themselves rather than the mechanisms which enable innovation (or "autonomous action" in terms of choosing to do things differently). That literature did, however, provide an initial program theory of how local health services could direct their own responses to the pandemic. Clearly there needs to be a *policy environment* which allows or even encourages local actors to make decisions about relevant aspects of service design and delivery [whatever those aspects might be (35)]. This could be seen in all four regions we conducted our ethnography, as the policy called for restrictions and temperament in services provided. Health centers responded by implementing innovating services to continue group care in Sweden and Australia, and setting up uniform points of contact and information in USA and Canada.

There have been endless calls for moves away from "one size fits all" service models, with assertions that policy which focuses on outcomes (accessibility and health outcomes) is likely to be more effective than policy which focuses on inputs. There also needs to be *local leadership* and champions, as seen in the implementation of the CVTAC in Canada, where imagination and creativity allowed local actors to recognize good ideas when they see them, and coordinated their implementation and ongoing operation.

This leadership is central to what is known as innovation capacity. The innovation literature (which rural health academics have only begun to recognize as applicable in their contexts) also talks about *absorptive capacity*, which is about building knowledge of what is possible and evaluating options in terms of their fit to the needs of the community. To that end, this ethnography serves as a primary investigation into the viability of performing a realist review examining what works where and for whom for innovative strategies in rural health services. Sites in Canada, Australia, and Sweden had diverse responses all of which conformed to the universal healthcare paradigm, and could be referenced in future with regards to rural health policy reforms.

Such knowledge should equally recognize why particular initiatives that appear successful elsewhere might not work in a particular location. There needs to be *collective mechanisms*, through which local actors engage with their communities and manage partnerships with external actors (including policy makers and "downstream" service providers). More recent literature has talked about an ability to implement change in such a way that perverse outcomes can be quickly identified and responded to and a process of continuous improvement can be undertaken which also recognizes unforeseen opportunities. This has been referred to as an *antifragile design* approach (36, 37).

The WHAT Framework

The pandemic brought with it changes in models of service delivery mandated by government health departments (38, 39). Largely these were around minimizing physical contact between service providers and users, so there has been a lot of attention paid to eHealth applications, automating paperwork

processes (such as electronic prescriptions in places which were not already using those), and reducing drop-in type services. Even here, though, there is scope for locally diverse action to ensure that implementing pandemic-inspired regulations did not unnecessarily reduce access to care and quality of care. Similarly, public health guidelines (such as minimum distances between people in various settings, conditions under which one might seek a COVID-19 test, maximum number of people for group-based activities) have needed to be interpreted at a local level.

A question for this project was not just "what sort of responses might local services implement?," but "what sort of responses would be visible to communities/service users?". The innovation literature in rural health (40, 41), such as it is, identifies three main types of local action –

1. Adopting (and very occasionally inventing) eHealth technologies;
2. Changing service structures
    a. Having different services or types of professionals change how they work together
    b. Changing how physical infrastructure is used
    c. Establishing a configuration of services targeted at specific populations or health conditions
3. Changing funding models or how funds are used locally.

In "normal times," these changes tend to occur over long periods of time, favoring "prudence" over "speed" (42). With the pandemic, however, rapid change was required, meaning that service managers had to quickly draw on their absorptive capacity. The speed with which new ways of doing things were implemented therefore reflects this aspect of the HOW framework and sits above the WHAT framework as "*evidence of preparedness*." In our research we had cases where health services (such as group counseling services) closed completely for a period without an alternative offer, indicating low levels of preparedness, and other cases where information about new processes and procedures was provided to the public almost as soon as new regulations were announced.

This provision of information is the cornerstone of WHAT local actors could do effectively. Information provision responses were of two types. The first was to inform community members about changes in how services were provided and accessed. One barrier to accessibility of rural health services is a division in the community between those who have the tacit knowledge about how the system works and how to access it, and those who do not. At the start of the pandemic, this division temporarily disappeared. We could then observe how local services distributed *guiding information*.

The second information impacts were local services taking on new or expanded *public health information* provider roles. Typically, public health information exists as standard (i.e., sourced externally in a standard format) brochures or posters inside health and care facilities or on community noticeboards. Rural communities are also often engaged in externally funded public health campaigns which may be implemented through local services, but typically involve outsiders visiting "the community" (school, aged care facility, community group) and doing presentations or workshops. These sorts of "pre-packaged" approaches were not able to keep up with community need for quickly provided information about the pandemic and its local impacts.

Guiding information was often necessary because of the *physical and procedural changes* that were made to service delivery. Within a care facility, this might have entailed new methods for making bookings (from a distance rather than in person), new ways of managing appointments (arrival and departure procedures, uses of waiting rooms), and changing the physical layout of the facility. There could also be changes in how care activities were distributed among the set of facilities that exist in a community (including non-care specific facilities like schools, meeting halls and so on).

The provision of timely, locally relevant, and broadly accessible information could of course be facilitated by changing how *digital communication technologies* were used. There was also a sense in which the pandemic "released the shackles" on using digital technologies in the actual process of care provision. Long persistent barriers to employing eHealth such as provider and user reluctance, regulatory and financial structures, concerns about quality of video and audio links and so on were swept aside as if by magic and non-contact care models were not just encouraged but mandated situations. Locally, service providers needed to quickly develop their own eHealth skills and help users to do the same. Local services could also choose to employ eHealth beyond the minimum if they saw opportunities to go beyond what was mandated.

Physical and procedural changes in service provision models and changing use of eHealth impacted *coordination between service providers* (and other stakeholders) within the community and external to the community. From a user perspective we could observe how "journeys" which involve a number of different providers were managed and the role of local actors in facilitating those journeys.

CONCLUSION

The lessons we can draw from the vignettes of rural health and care systems presented in this article follow along two lines: theoretical and operational. Theoretically, the COVID-19 pandemic has resulted in extreme levels of stress on local health and care systems and our evidence has shown examples of where these have flourished and provided new models of care or new services for rural communities. Rural organizations are well-conditioned to uncertainty given often limited and temporary funding, high turnover of the professional workforce, and shifting priorities of regional and state and/or provincial governments. As such, they have developed a high absorptive capacity given the need to adapt to frequent change.

Operationally, three key features have come forth as being paramount to successful innovation and response in rural

communities and care systems, captured in our WHAT and HOW frameworks. First, there needs to be a high degree of collaboration and connection. This collaboration is not only internal to the communities themselves, but also with government at higher levels, private business, and social enterprises. Much of these connections already exist in the small places we studied, but our successful examples all included collaboration from numerous stakeholders. Second, there needs to be a high level of familiarity and knowledge of *local* environments. The axiom that all rural communities are unique appears to hold true, where knowledge of how services are used, who provides them, and who uses what services is essential to program success and adaptation. Third, there needs to be creativity in how limited resources can be managed and adapted, including using new technologies. The most successful examples we profiled responded to a resource shortage with new technologies and an adaptation to the local community context.

This article has shown the potential for innovation in rural communities and in rural health and care systems. Rural health and care systems can be loci of adaptation and innovation given the appropriate mix of local autonomy, strong service-community connections, high absorptive capacity, and evidence of organizational antifragility.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

SP, DC, and PP wrote and edited the manuscript. SP, DC, PP, A-KH, HH, ML, HS, MO, JB, MGG, MS, and JG performed research and contributed their findings to the manuscript. All authors contributed to the article and approved the submitted version.

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What Have We Learnt About the Sourcing of Personal Protective Equipment During Pandemics? Leadership and Management in Healthcare Supply Chain Management: A Scoping Review

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Introduction: During the ongoing COVID-19 pandemic there have been much publicised shortages in Personal Protective Equipment for frontline health care workers, from masks to gowns. Recent previous airborne pandemics provide an opportunity to learn how to effectively lead and manage supply chains during crisis situations. Identifying and plotting this learning against time will reveal what has been learnt, when and, significantly, what can be learnt for the future.

Aims: (i) To identify the temporal trajectory of leadership and management learning in health supply chain management through pandemics and (ii) to identify leadership and management lessons to enable the resilient supply of key items such as PPE in future pandemics.

Methods: We undertook a scoping review in line with PRISMA (scoping review extension) searching Business Source Premier, Health Business Elite, Medline, ProQuest Business Collection and PubMed. Search terms were focused on recent airborne pandemics (SARS; Ebola; Zika virus; H1N1 swine flu, COVID-19), supply chain management, PPE, leadership, learning, inhibitors and facilitators and resilience e.g., SARS AND supply chain* AND ("personal protective equipment" OR PPE) (leaders* OR manage*) Titles and abstracts were downloaded to Endnote and duplicates removed. Two authors independently screened all of the titles and abstracts. Inclusion criteria focused on leadership and management in health supply chains during pandemics, peer reviewed or grey literature (either from business journals or reports): exclusion criteria included not in English and not focused on a named pandemic. Once interrater reliability was assured, authors completed a title and abstract screening independently. Ten percent of the resultant full text articles were screened by both authors, once agreement was reached the full text articles were screened independently noting reasons for exclusion. A data extraction tool was designed to capture findings from the final articles included in the review.

Results/Discussion: We found 92 articles and, after screening, included 30 full text articles. The majority were focused on COVID-19 ($N = 27$) and most were from the USA ($N = 13$). We identified four themes related to leadership and management of pandemic PPE supply chains, (i) *Leadership and management learning for pandemic PPE supply chain management*, (ii) *Inhibitors of PPE supply chain resilience during a pandemic*, (iii) *Facilitators employed to manage the immediate impacts of PPE supply chain demands during a pandemic,*and (iv) *Facilitators proposed to ensure longer term resilience of PPE supply chains during pandemics* Our study suggests there has been limited leadership and management learning for PPE supply chains from previous pandemics, however there has been extensive learning through the COVID-19 pandemic. Lessons included the importance of planning, the significance of collaboration and relationship building. Resilience of PPE supply chains was reported to be dependent on multiple levels from individuals to organisation level and also interdependent on (i) sustainability, (ii) the practise of PPE and (iii) long term environmental impact of PPE suggesting the need, long term, to move to a circular economy approach.

Keywords: supply chain management (SCM), leadership, pandemic, COVID-19, personal protective equipment (PPE), supply chain, resilience

INTRODUCTION

As a result of the Covid-19 pandemic there has been much attention internationally about the sourcing manufacture and supply of personal protective equipment (PPE) including surgical gowns, gloves and masks. Personal Protective Equipment (PPE), defined by OSHA19 as "specialised clothing or equipment worn by an employee to protect against infectious materials, which plays a key role in preventing the spread of infectious respiratory diseases (1–3) as well as the safety and well-being of healthcare workers and broader society in that it acts to break the chain of infection (4). PPE is a sector that has traditionally been dominated by a few global suppliers and due to the pandemic saw unprecedented demand along with the interruption of the manufacture and delivery of supplies (5). These supply issues are coupled with the lack of visibility of supply and the commonality of governments and healthcare procurement agencies buying through third parties which has further increased SC vulnerabilities (6). Such vulnerabilities have resulted in calls for greater transparency and understanding in terms of how PPE supply chains are managed and the factors that enable or inhibit their level of preparedness for critical events such as pandemics (5).

The management of supply chains relies on the active and systematic flow of goods and services, which includes all processes that transform raw materials into final products. One pre-COVID-19 US study reviews the lessons learned from the responses to the 2009 H1N1 influenza pandemic and the 2014 Ebola virus epidemic (2). It is evident that the PPE supply chain (manufacturing, distribution, and ordering) is complex, and a significant proportion of PPE goods is produced offshore and therefore likely to be slow to respond to any unexpected changes in demand. The upsurge in demand during the pandemic was not the only issue, the uncertainty relating to how long the response would last and how much produce would be needed also posed challenges in determining production and the increased capacity required. The importance of clear guidelines on the use of PPE has also been noted as a cause for concern, along with the need to coordinate supplies across regions so that stock can be moved quickly to where it is needed. Therefore, partnering with other facilities and suppliers was also critical.

COVID-19 pandemic was not the first outbreak to draw attention to the use and supply of PPE. Interest was heightened following the SARS outbreak of 2003 and the terrorist attacks around the 1990s and early 2000s (7). Despite the realisation of the importance of such equipment, the lessons learnt seem to have been limited (8) and possibly not reached those key decision makers in terms of how the PPE supply chains should be managed. This is evident by the fact that there is a lack of reporting regarding PPE and infection prevention and control protocols (9) in their work addressing the West African filovirus disease outbreak. The lack of standardisation for approval of use of PPE is also an issue (7), particularly in conditions like the ongoing pandemic where PPE may have to be shipped across countries, depending on supply and demand, where approval standards for using PPE could be different (10). These previous outbreaks have been an opportunity for learning in terms of how PPE supplies should be managed.

Despite having this knowledge of the PPE supply chain, most of these issues were witnessed again during the COVID-19 pandemic, especially during the early stages. Interruptions to supply resulted in the lack of PPE and an inequitable distribution (10). Global shortages of PPE were reported which were worsened due to the fact some items of PPE had to be worn not just by medical staff but the entire population. This surge in demand was exacerbated by panic buying and excessive stockpiling, which amplified the disruption in supply chains (11–13). The increased demand also resulted in an inflation in price

due to the lower PPE stocks (10). Further problems in supply were due to the restrictions in travel, which saw countries having to start manufacturing and supplying their own PPE, which with the immediate need for the equipment raised questions regarding their approval for use according to existing standards which varied across countries (10). Understanding standards and product labelling is challenging, particularly as this is likely to vary between products. Frontline staff have likely used and been trained for particular brands and therefore introducing new equipment may require additional training or guidance.

As noted earlier most of the PPE used in Europe is produced offshore and there is a high reliance on a few global suppliers (14). Medical face masks, which are almost exclusively produced in China, have been in short supply during the COVID-19 pandemic in many industrialised countries which do not produce them (15). Strict lockdowns and other pandemic related restrictions imposed in supplier countries exacerbated this situation.

Critical disruptions in the PPE supply chain have also led to restrictions on the export of raw materials and supplies (13). Domestic shortages of PPE and the high uncertainty about future demand has led to governments and business leaders to be cautious. The shortages have also driven many domestic companies to rapidly reconfigure their supply chains (15). For example, the manufacture of facemasks in China rose from 20 million facemasks per day in January 14 to about 116 million per day at the end of February (16). In the UK, there were several organisations which repurposed their existing manufacturing facilities to make PPE (1, 17, 18). The reaction to the shortage of PPE in the UK has also come from perhaps some other unlikely sources. For example, the British fashion retailer Barbour is producing protective gowns (19). Burberry retooled its trench coat factory to non-surgical gowns and masks for patients (19). Louis Vuitton also announced they would be producing masks for front line workers along with their perfumeries such as Dior switching production to hydro-alcoholic gel hand sanitizer (20). Such innovations have enabled firms to extend their supply chains by creating separate channels of supply through the use of alternative and in some cases local providers or by restructuring international purchasing operations (15, 21). This rapid reconfiguration of supply chains has given rise to temporary supply chains, where rapid action must be taken in an uncertain and emergent environment (22). Suggestions have also been made that there is a need to use parallel supply chains for such critical items (4).

Although over the course of the pandemic the supply of PPE has stabilised, the initial problem was sufficient to highlight the lack of preparedness of almost all governments worldwide. For example, a recent review of the procurement and supply of PPE in England (4) during the early stages of pandemic showed that stock levels were dangerously low and required action from organisations outside of the sector to supplement supplies. The aim therefore of this scoping review is to (i) To identify the temporal trajectory of the learning for the leadership and management of PPE supply chains through pandemics and (ii) to identify leadership and management lessons to enable the continued supply of key items such as PPE in future pandemics.

METHODS

The use of scoping studies to synthesise research evidence is becoming increasingly popular (23). The field of supply chain management extends beyond academia and therefore a scoping review was undertaken in order to capture relevant grey literature. Factors to consider when undertaking a scoping review have been refined over the years (23, 24) though the same principle stages, identified by Arksey and O'Malley (25), remain in place: 1. Identifying the research question; 2. Identifying relevant studies; 3. Study selection; 4. Charting the data and; 5. Collating, summarising and reporting the results. We followed this structure to report our methods and findings.

Stage 1. Identifying the Research Question

The aim and objectives for this study have been outlined in the introduction.

Stage 2. Identifying Relevant Studies

We took a systematic approach to identifying articles relevant to the research aim following the PRISMA ScR extension (26). With the guidance of a specialist health management librarian, we identified five databases to interrogate: Business Source Premier, Health Business Elite, Medline, ProQuest Business Collection, and PubMed. Search terms related to virus disease infection pandemics, supply chains and leadership and/or management and resilience were established following discussions and trialling of test search terms. The final search ran as follows: [(SARS OR Ebola OR Zika virus OR H1N1 swine flu OR COVID-19 OR coronavirus) AND supply chain* AND ("personal protective equipment" OR PPE) AND (leaders* OR manage*)]. Duplicate references were discarded, and reference lists were mined to identify additional resources.

Stage 3. Study Selection

Two reviewers (SB and SW) analysed all the title and abstracts independently applying inclusion and exclusion criteria (**Table 1**) using Rayyan (27) a web tool designed to promote expeditious collaborative systematic literature review. We included articles reporting empirical studies, reviews and commentary articles from peer reviewed studies and business reports. Studies not focused on the leadership and/or management of health PPE supply chains, including resilience, during a pandemic were not included. We were particularly interested in those publications recording lessons learnt and/or recommendations for managing PPE in future pandemics.

Results from the independent title and abstract screening were reviewed by both members of the research team. Conflicts and articles coded as "maybe" were discussed and a resolution to either include or exclude was identified. The full texts of the remaining articles were assessed (SB and SW) for inclusion using the inclusion and exclusion criteria in **Table 1**.

Data Analysis

We used a conventional content analysis approach which is commonly employed with study designs aimed at describing a phenomenon (28). Here, the study intention is to respond to the research aim and objectives focusing on the phenomenon

TABLE 1 | Inclusion and exclusion criteria for articles.

Inclusion	Exclusion
Focus on supply chains, SCM and PPE and Pandemic and Leadership/Management	Focus on impact of lack of PPE or clinically focused
Empirical studies, reviews and commentaries/opinion pieces	No abstract
	Not in English
Grey literature: professional/business journals and reports	Grey literature: newspapers

of supply chains during pandemics. Data related to leadership and/or management and barriers and/or enablers to supply chain resilience were extracted from the final selected articles.

RESULTS

Stage 4. Charting the Data

Once duplicates were removed, we identified 92 articles for review. Title and abstract screening reduced this number to 45. One record was not retrieved, and four additional texts were added from citation mining and after full text screening we had a final selection of 30 articles for analysis. **Figure 1** shows details including reasons for full text exclusions.

Characteristics of Final Papers Selected

The majority of papers reported on PPE supply chains in relation to COVID-19 ($n = 28$) with only two reporting on either Ebola or H1N1. Of the 29 papers reviewed 27 were published since 2019 with only two being published between 2014 and 2017. Many papers were from the USA ($n = 13$) with two referring to global supply chain issues and several ($n = 8$) not reporting their location. Seventeen papers were peer reviewed and 13 sources were from the grey literature. A summary of the papers can be found in the table provided in the **Supplementary Material**.

Stage 5. Collating, Summarising, and Reporting the Results

Data were extracted in relation to the leadership and management learning of PPE supply chains during a pandemic. Resilience was a common topic and so inhibitors and facilitators of resilience were also extracted. Here we present the findings by theme.

Leadership and Management Learning for Pandemic PPE Supply Chain Management

National health security is dependent on the medical supply chain, therefore leadership around the supply of PPE is critical (30, 31). Even prior to the COVID-19 pandemic we have seen global supply chains grow leaner and lacking to cope with disruptive challenges (30). It was noted that providers can only prepare as well as their leadership teams direct them (32). Leadership has been reported at various levels from international policy to individual team members. On the international stage high level leadership decisions impacted on the global PPE supply chain. China produces about half of the international supply of surgical masks and ramped up their production however they then stopped all mask exports (along with other countries such as Germany) leading to a global shortage (33). Decisions to stockpile exacerbated PPE shortages (33, 34) further compounded by unexpected consumers demand (35). However, organisational leadership was reported to be critical in setting the pace and tone of activity along the PPE supply and was reported to have been found lacking at critical decision points (32). The eventual lack of resources, PPEs and equipment exposed the healthcare supply chain fragility and dependency (5). Although failures in leadership were directed at stockpiling of PPE (32) others pointed to the under-preparedness of the PPE supply chain, the lack of policies (32, 33, 36, 37) seen in combination with a fragility of the system (38) and a lack of trust between stakeholders (33). There were calls to promote the transparency along the supply chain (36) to ensure both supplier and provider understand what is available at various stages of production and awaiting distribution (2).

The need for leaders to set up robust planning was a repeated theme with the need to plan centrally and implement locally identified by several authors (5, 30, 39) to improve transparency in the supply chain and contemporaneous access to PPE (30, 37). Additionally, there was the need to plan based on disaster type (i.e., how it spreads) and based on unique features of the type and usage of PPE (39), with some authors referring to how humanitarian supply chains are managed (5).

Collaboration and relationship building was reported as central to successful leadership and management of PPE supply chains (40–43). There is a need to ensure all parts of the supply chain are involved and engaged to promote the open innovation required to manage disrupted supply chains across organisational and national boundaries (33). There was a call for a reorientation of the practises of supply chain management with closer collaboration of suppliers and end users to develop projects in partnership with local industries (5). A particular challenge for the leadership of supply chain with the disruption caused by pandemics is that buyers rarely have the logistics knowledge and experience to manage a radically altered supply chain (42). Here building relationships has been central to enabling PPE supply chain pivot (38, 39).

Leadership at the team level was commonly reported to lead to benefits. For example, the team efforts required to meet the PPE supply chain demands led to a strengthening of interdepartmental relationships leading to greater interdependency within and between teams who could then rely on each other (40). Some leaders saw the demands of the pandemic as an opportunity to develop initiatives and partnerships they had been developing for some time and welcomed the opportunity to think beyond the traditional healthcare silos (38). Network formation and coordination was seen as important with three relationship types noted–new, established and established weak ties (44). This broadening of relationships supports diversity in the supply chain: previous pandemics have highlighted the need to encourage manufacturers to think expansively about sourcing for PPE

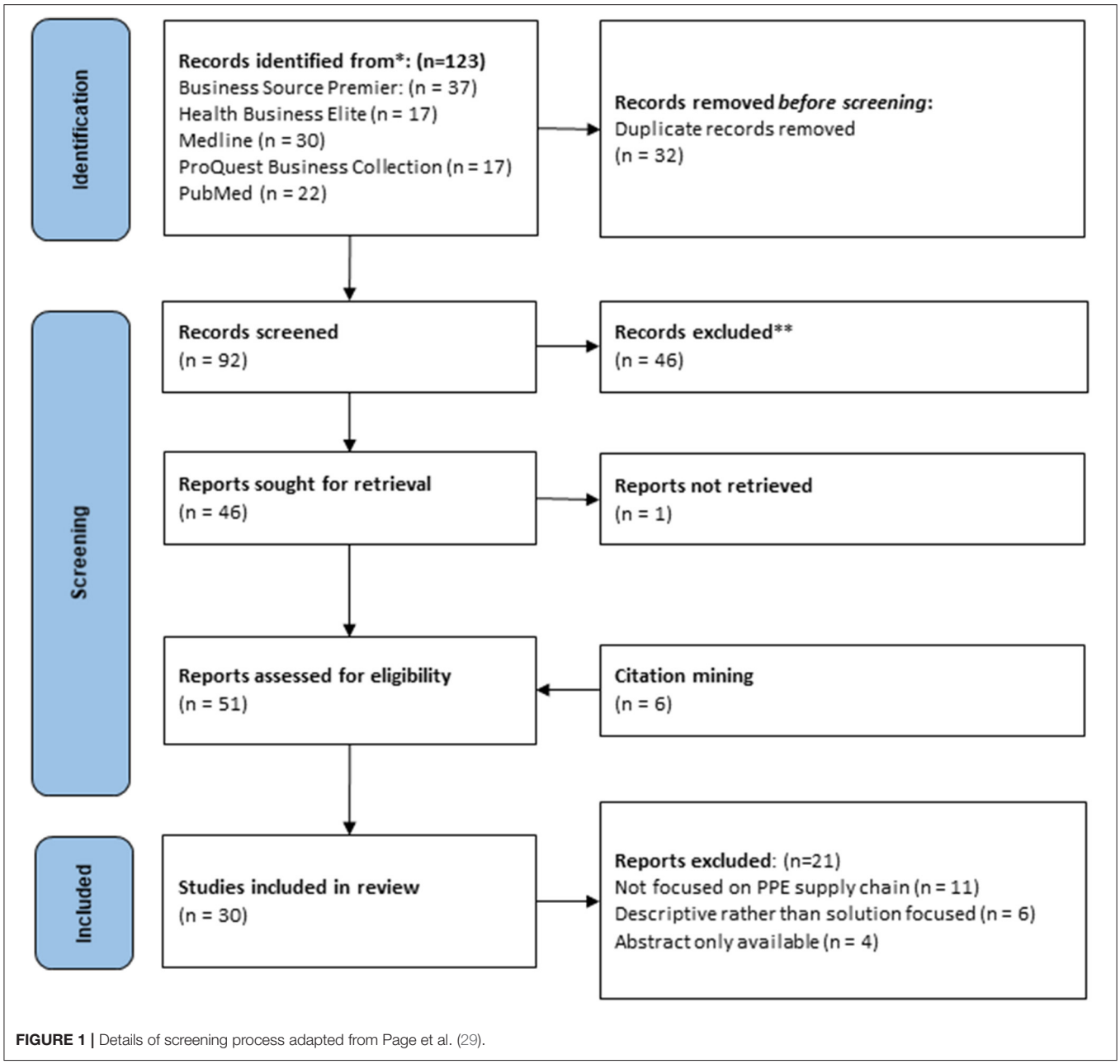

FIGURE 1 | Details of screening process adapted from Page et al. (29).

and promote diversity (37, 40). New relationships extended not only to the sourcing and manufacturing of PPE but also to the usage of PPE (e.g., healthcare organisations working with local councils).

A novel experience was the impact of volunteers in the workplace as part of seeing people stepping up (40, 41). People taking up new roles outside the workplace, for example, people using 3D printers to make masks referred to as the "citizen supply chain" with patterns shared freely (45). Additionally, within the workplace cross training of staff was reported to increase flexibility and agility to respond (40, 42, 46). However, caution was expressed with a need to see these responses well-coordinated (41) to ensure user safety is not compromised (47).

Many authors provide suggestions for leaders to consider when looking to the future. Importantly there is a need to take time to reflect and then refine strategic plans (41, 48). There was a call for predictive tools that are bi-directional to anticipate demand though leaders and managers need to be able to trust the tool (32). The need for flexible and agile structures to be in place was reported in order to accommodate local and national PPE needs while ensuring visibility, resilience and responsiveness (30, 32, 49). Core components of agile PPE supply chains, to ensure responsiveness to pandemics, include flexibility, transparency, persistence and responsiveness, globally independent and equitable (36). During times of pandemics leaders who want to not only survive but also to thrive need to consider how they create value for their

clients, prioritise breakthroughs over continuous improvement, collaborate, mitigate risk through shared funding and building resilience in local supply chains (41).

Inhibitors of PPE Supply Chain Resilience During a Pandemic

The leadership and management learning reported above present some of inhibitors to a resilient PPE supply chain. Additionally, there were reports of the overdependence on the few countries that have traditionally mass-produced PPE (33, 50). Despite experience from previous outbreaks, pandemic or other crisis (e.g., Hurricane Katerina) a failure to learn was identified, specifically the lack of cohesive strategy for PPE (2, 51). Previous supply chain practises including Lean, just-in-time (JIT) inventory and low unit of measure (LUM) were reported to have not promoted resilience to endure the surge demand of a pandemic (35, 52). Although the value of developing PPE supply chain resilience was recognised, there was acknowledgement that there was no quick fix to developing resilience, particularly while having to focus on immediate demands (35, 51). There has been a, perhaps understandable, unwillingness on behalf of manufacturers to invest the additional resources that would promote resilience and a need for commissioners to accept PPE may need to cost more (33). This will be challenging for some organisations who have experienced a loss of income from elective surgery leading knock-on effects on the supply chain (35) which has a knock-on effect on sustainability. Others point to the disorganisation of supply chains and bureaucratic inefficiencies that compromise preparedness for pandemic demands (33). Overcoming these barriers will require collaboration of key PPE suppliers, government reforms and reduction in "red tape" (47).

Schumacher et al. (14) suggest that the COVID-19 pandemic is an event that has exposed the varied global supply chain vulnerabilities and dependencies. Drawing on the work of Chopra (15) and Park et al. (13), they summarise these as being: stockpiling, capacity overload, rapid supply configuration, reduced or no visibility of the upstream supply chain; supply shortages, capacity loss in production and warehousing, *ad hoc* supply to end users without regular conformity checks and surging demand.

Facilitators Employed to Manage the Immediate Impacts of PPE Supply Chain Demands During a Pandemic

Lessons from previous pandemics point to the need for action at the community, clinician, day to day supply chain management levels. For example, at the community level, the Mayo clinic ran a "Lead by Example" campaign to encourage health care workers to promote the appropriate use of PPE when outside work (53) and so reduce unnecessary demand on the supply chain. The community also became directly involved in supply chain by making PPE, circumnavigating global supply chains. Availability of open-source designs for PPE, were freely shared to facilitate others to reproduce PPE e.g., face masks using 3D printing (45). This openness and transparency can lead to building long term relationships that could last beyond an immediate pandemic (38). For clinicians, there was a need to provide them with clear and consistent guidance on PPE usage to ensure they can stay safe while also preserving supplies (2, 53). Here, clear, timely and reliable communication was essential. Finally, at the day-to-day supply chain management level, improving the visibility of the demand and supply of PPE (2) and undertaking predictive surge modelling to promote transparency of available PPE supplies is needed to permit proactive planning (53).

Facilitators Proposed to Ensure Longer Term Resilience of PPE Supply Chains During Pandemics

A pandemic reinforces the significance of resilience and sustainability in supply chains and use of PPE, including the overuse of single use items (35) and several authors reported approaches to longer term sustainability of the supply of PPE, including the need to learn from previous pandemics (2, 32). Views on stockpiling varied with some in favour of early stockpiling (34) and others seeing this approach as hoarding (so reducing visibility of what stock is available) (36). However, ultimately health care supply chains need more diversification, localised systems and to move away from global supply chains in order to build more resilient communities (30, 32, 35, 52) with Handfield going further and noting core attributes for a supply chain fit to withstand a pandemic including flexibility, traceability and transparency, persistence and responsiveness and equitable access (30).

There was a call for innovation in conserving, obtaining and stock supplies (35). However, ensuring the production and delivery of safe and effective PPE is paramount. The lack of international standards for PPE was recognised (36) with calls to develop standard manufacturing protocols (e.g., for 3D printing for PPE) (45). To mitigate risk Schumacher promotes the need to be aware of what is happening up and down stream of the supply chain, setting up formal inspection processes where required (14).

DISCUSSION

Themes identified from this review related to leadership and resilience, (i) Leadership and management learning for pandemic PPE supply chain management, (ii) Inhibitors of PPE supply chain resilience during a pandemic, (iii) Facilitators employed to manage the immediate impacts of PPE supply chain demands during a pandemic, and (iv) Facilitators proposed to ensure longer term resilience of PPE supply chains during pandemics, describe the phenomenon of PPE supply chains during pandemics. First, the importance of leadership at all levels from government and individuals noting critical features such as planning, collaboration and relationship building. Second, barriers to resilience focused on historic PPE sourcing and traditional supply chain practises (e.g., JIT). Third, facilitators for resilience applied in practise included actions for multiple levels including, community, clinician and day to day supply chain management and stressed the importance of communication. Finally, some facilitators of resilience were proposed to support longer term benefit and diversification and delivery of supply chains closer to home.

TABLE 2 | Comparison of Supply chain issues identified from Pre and During the COVID-19 pandemic.

Supply chain issues	Pre-COVID-19	During COVID-19
Difficulties in predicting demand and supply	✓	✓
Overordering and stockpiling of PPE	✓	✓
Placing orders with multiple vendors	✓	✓
No-centralised order monitoring system	✓	✓
Reliance on a few global suppliers	✓	✓
Product use affected by regulatory requirement	✓	✓
Lack of SC strategies and policies		✓
Supply chain practises lacked resilience		✓
Reduced or no visibility of the upstream supply chain		✓

One of our study aims was to report on the temporal trajectory of leadership and management learning for PPE supply chain management through pandemics. Surprisingly, only 2 of the final 29 articles reported on pandemics other than COVID-19 e.g., Ebola or H1N1. This is not to suggest there has been no learning from previous pandemics (54, 55), rather that the focus to date has not been on supply chains. Although several papers note the importance of learning lessons from previous pandemics [e.g., (56)] without a previous focus it is difficult to collate these into learning points for leaders and managers of PPE supply chains. The surge of papers centred on supply chains since COVID-19 may indicate previous pandemics did not experience any supply chain issues, or that there was a focus on other areas (e.g., clinical topics). The locations impacted by earlier outbreaks/pandemics (e.g., largely low-to-middle income countries) may not have attracted as much attention from academics, with exception of those studying humanitarian supply chains.

If we compare the key lessons that were recorded from Patel et al.'s (2) study of supply chain issues arising during the public health emergency response to Ebola with the more recent findings from our scoping review (**Table 2**). This would suggest that many of the issues were experienced during outbreaks prior to COVID-19 but not on the global scale recently seen. If we examine these issues many of them relate to those akin with supply chain vulnerabilities (5, 6, 13–15).

Future focus for leaders and managers in this field should include reviewing pandemic plans at national and local levels to establish whether learning from the COVID-19 pandemic, including diversifying supply chains and establishment of international standards for PPE has been instigated. Careful and ongoing monitoring of pandemic preparedness plans is clearly essential to avoid the disruption of the supply of PPE experienced globally through the COVID-19 pandemic. Decisions around being largely dependent on single global suppliers need to be reviewed considering recommendations made for at least dual sourcing and the use of parallel supply chains. This diversified supply chain could also be taken from a geographic perspective to limit the supply-side risk from one country, which includes the development of local suppliers. However, in the short-term there may well be a need to build robust inventories of PPE to buffer against other supply chain disruptions and longer term to consider regulation of PPE and the PPE supply chain to ensure standardisation (14, 33).

While examining resilience, several papers referred to sustainability. Even though the environmental impact of PPE was not the focus of this study it is clear that i) sustainability, ii) the practise of PPE i.e., discarding PPE easily, when not necessary, and iii) long term environmental impact of PPE are interconnected and difficult to disentangle. The circular economy proposes a move away from a linear business model where resources are consumed with a primary focus solely on the end goal (57). Instead, the circular economy seeks to breakdown functional silos, minimise waste, keep resources in use as far as is possible and enable end-to-end visibility, collaboration, and optimization (57, 58). Leadership lessons from this review feed into the development of a circular economy for PPE supply chain

TABLE 3 | Comparison of key supply chain lessons identified from Pre and During the COVID-19 pandemic.

Supply chain lessons	Pre-COVID-19	During COVID-19
Tiered approach to categorise hospitals e.g., frontline facility, assessment hospitals, and treatment centres	✓	
Improve guidance: Include standards on products and guidance on how much of each product might be needed during a response	✓	✓
Monitor PPE use and distribution to minimise inappropriate purchases and improve overall distribution across the healthcare system.	✓	✓
Establish or centralise visibility on orders placed—need to reduce duplicate orders and understand true demand	✓	✓
Share supplies—Facilities within a community/regions should be encouraged to have plans in place to share products during an emergency	✓	✓
To have mechanisms in place to encourage the supply chain to have elasticity in the system to allow for increased supply in response to increases in demand need to be explored.	✓	✓
Investigate where to hold stock within the system in order to respond to increases in demand e.g., at the distributor, manufacturer or healthcare provider.	✓	
Improve domestic/local manufacturing surge capacity at the time of an event	✓	✓
Sharing of information and regular communication e.g., clear product specifications, demand information.		✓
Develop collaborative partnerships beyond the traditional healthcare silos	✓	✓
Increase visibility and transparency of supply chain practises		✓
Develop a framework for governance and response to enable a globally independent supply chain.		✓

management. For example, the importance of communication where for instance clinicians promote conservation of PPE resources and reduce waste. Equally it is essential frontline staff are protected, therefore communication must be timely, accessible, up to date and accurate.

Following this, despite persistent shortage of PPE in some areas, there was a shift to understand the issues faced by people wearing PPE. Problems that came with the utilisation of PPE varied from, a need for more training regarding the donning and doffing (use) of PPE, lack of confidence regarding their use or an understanding regarding their level of protection provided, and adverse effect associated with use of PPE, especially over longer periods of utilisation (59, 60). And finally, at present with the tapering of the pandemic in some countries, attention is now being given to the disposal and environmental impact of PPE, which is not only related to the various ecosystems but also to infection control for those dealing with the PPE related waste management (61, 62).

If we again examine the temporal learning in terms of whether the lessons from earlier outbreaks are similar to those already emerging from literature concerning the COVID-19 pandemic. It would seem from comparing some of the key lessons from Ebola (2) and those presented from this review it would suggest that many of these were known (see **Table 3**).

Limitations

We actively sought literature focused on the PPE supply chain during pandemics. Our search returned a limited number of papers relating to any pandemic other than COVID-19. Other broader literature from previous pandemics such as SARS or H1N1 may include some discussion about PPE supply chains and could be scoured to ensure no leadership or resilience lessons have been missed. Similarly, our selection of databases used for this review could have excluded some papers of interest.

Conclusion

Sourcing Personal Protective Equipment (PPE) has been a global challenge for health systems during the COVID-19 pandemic. Such experiences are not new, for example Ebola, SARS. Yet global supply chains were still not sufficiently prepared or resilient to meet the demand. Learning and enacting lessons is essential to develop agile and sustainable solutions to ensure supply of appropriate and quality assured PPE in the event of future pandemics. The aims of this study were to focus on those lessons to be learnt by those involved in the leading and managing the sourcing of PPE and to identify the enablers and inhibitors to developing a continued and resilient source of supply, particularly during a pandemic.

Our review of the relevant literature suggests there has been limited leadership learning for PPE supply chains from previous pandemics, particularly around supply chain issues. However, there has been an increased attention on the PPE supply chain during the COVID-19 pandemic, which has led to the dissemination of the learning. Lessons included the importance of planning, transparency, the significance of collaboration and relationship building, which need to be in place long before the outbreak occurs (39). Healthcare systems are better prepared for pandemics or disasters when engaged in processes that can respond in a time of crisis. Arabi et al. (63) state the lessons learned from the COVID-19 pandemic should not just be contingency planning for times of "stress" but should reflect new habits that will strengthen the levels of preparedness for future events.

Resilience of PPE supply chains was reported to be dependent on multiple levels from individuals to organisation level and also interdependent on (i) sustainability, (ii) the practise of PPE and (iii) long term environmental impact of PPE suggesting the need to move to a circular economy approach. Such practises would enable supply chain tracking, tracing, and responsiveness supported by multiple levels of stakeholders—individual, organisational, supply chain, governmental, and community (57). However, Chopra (15) reminds us that there is a balance to be struck between efficiency and resilience, where organisations need to be prepared for a "shock" which is likely to be expensive, but at the same time the shock may never happen. He warns the biggest mistake is for manager so severely underestimate the probability of it happening.

Most studies in this review were based in higher income countries (such as the USA). As the global implications of COVID-19 become apparent it is evident that future research must include the leadership lessons from and for low- and middle-income countries to ensure the potential for an international response. Learning and enacting lessons is essential to develop agile and sustainable solutions to ensure a sustainable supply of appropriate and quality assured PPE in the event of future pandemics.

In this review we have limited our search to PPE and healthcare supply chains. However, it is evident that the challenges faced during the COVID-19 pandemic are similar to those when handling humanitarian issues in distributing relief items such as medicine and food as equitably as possible to the areas impacted by a disruptive event. Learning from other supply chain disruptions such as the Japanese tsunami could also provide some generic insights to supply chain vulnerabilities and resilience. Future research should therefore expand to draw lessons from learning from others industries how to mitigate supply chain disruptions [e.g., (64)] along with studying the responses seen from the humanitarian supply chain research [e.g., (65, 66)].

In 2006 Hick and Thorne reviewed the general lessons around the use, types and selection of PPE for emergency medical care and decontamination, they concluded their paper with the following statement: "*We can only hope that we are not forced to learn too many more harsh lessons about PPE use in the future. In the meantime, however, we should strive to prepare our communities by selecting appropriate protective technologies in relation to perceived threats and practising our responses so that our personnel are comfortable using their PPE and understand the consequences of not doing so*" [(7), p. 9]. The findings presented in this scoping review, suggests that more harsh lessons have been learnt from the

disruptions during the COVID-19 pandemic particularly for those charged with leading and managing the supply of PPE. Corporate decision-makers when (re)designing supply chains need to "stress-test" for key performance measures such as resilience, responsiveness and reconfigurability. as well as focusing on traditional measures such as cost, quality, and delivery.

DATA AVAILABILITY STATEMENT

Articles informing this study are freely available. References are included in text and in the reference list. Requests to access the datasets should be directed to stephanie.best@mq.edu.au.

AUTHOR CONTRIBUTIONS

SB and SW co conceived the study, developed the study design, undertook data collection and analysis, and co wrote the first draught of the manuscript and the final submission. All authors contributed to the article and approved the submitted version.

SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2021.765501/full#supplementary-material

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COVID-19 and Health Systems Functioning in Sub-Saharan Africa Using the "WHO Building Blocks": The Challenges and Responses

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Sub-Saharan Africa (SSA) has made major progress in improving access to health care over the past three decades. Despite efforts made toward achieving universal health coverage, the health systems of countries in the sub-region are inundated by a myriad of challenges that have become more virulent amid the COVID-19 pandemic. This paper discusses the health systems challenges and responses in SSA amidst the COVID-19 using the World Health Organization's (WHO) building blocks of health systems functioning. Long-lasting abysmal health system financing and insufficient government investment in SSA pose major challenges to the effective health systems functioning amid the COVID-19 pandemic. This situation also makes it difficult for the health system to meet the demands of the COVID-19 pandemic and at the same time, cater for other essential health services. Countries in SSA must prioritize the reformation of their health systems through effective health system policy development and implementation, human resources development, training, service delivery, governance and regulation, and sustainable health financing.

Keywords: COVID-19, health systems, sub-Saharan Africa (SSA), WHO building blocks, perspective

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INTRODUCTION

In December 2019, a novel coronavirus (SARS-CoV-2) which causes the coronavirus disease 2019 (COVID-19) was isolated in China (1). The WHO on March 11, 2020, declared COVID-19 as a global pandemic after a rapid spread of the virus (2) which has caused a worldwide disruption to health systems. Over the past 2 years that the virus broke out, about 386,548,962 confirmed cases including 5,705,754 deaths have been recorded as of 2nd February, 2022 (3). At the same time the world is making all efforts to reduce the burden and mortality of the pandemic through vaccination with a total of 10,040,768,270 vaccine doses being administered (3). Health systems constitute the foundation for achieving the third sustainable development goal (SDG) of ensuring health for all at all ages by the year 2030 (4). A health system refers to all activities whose primary purpose is to promote, restore, and maintain health (5). The primary aim of every health system is to protect and improve the health of the people, hence it is concerned with people's health (6). Despite efforts made over the years toward achieving health for all, the health systems of SSA countries are undermined

by a myriad of challenges which have been exacerbated by the COVID-19 pandemic. Key challenges in the health system in SSA include inadequate human resources, insufficient financing through low budgetary allocation, inadequate availability of essential medicines, and poor leadership and management (7). This paper discusses the challenges and responses in strengthening health systems in SSA in the midst of the COVID-19 using the WHO building blocks of health systems functioning. The building blocks constitute the WHO framework that describes health systems in terms of six core components comprising service delivery, health workforce, health information systems (HIS), access to essential medicines, financing, and leadership/governance (6) (**Figure 1**).

Using the health systems building blocks, the key research question of this paper is: What are the delivery, health workforce, health information systems (HIS), access to essential medicines, financing, and leadership/governance challenges and responses toward ending the COVID-19 pandemic in sub-Saharan Africa?

SERVICE DELIVERY

Effective health service delivery is central to the achievement of the health-related Sustainable Development Goals (SDGs), which include the delivery of interventions to reduce child mortality, maternal mortality and the burden of HIV/AIDS, tuberculosis and malaria by the end of 2030 (4). In SSA, healthcare is mostly provided at five functional levels. These are Community (health posts), sub-district (health centers and clinics), District (District Hospitals/health directorates), Regional (Regional hospitals/health directorates) and national (tertiary/quaternary hospitals). Health service delivery is the immediate output of the inputs into the health system, such as the health workforce, procurement and supplies, financing and governance (6). COVID-19 has exposed the deficit in health services prevailing in SSA. The inadequacy of laboratories and testing kits in most SSA countries to carry out mass laboratory testing of samples collected from suspected COVID-19 cases has resulted in delays in testing. In most cases, it takes more than the recommended 2–3 days to receive results. Also, the limited number of beds and other facilities including lack of isolation centers has led to the premature discharge of COVID-19 patients to go self-isolate in their various homes while no specific strategy is put in place to follow them up (8).

There have been some successful responses across the sub-region toward improving healthcare access in terms of the availability of health facilities. Many governments are investing in building more health facilities and specialized centers. For instance, the Ghana government with funds from the private sector put up the first infectious disease isolation and treatment center; Ghana Infectious Disease Centre (9). This is consistent with the suggestion by Gebremeskel et al. (10) that private sector involvement in health system financing and administration has the potential of resolving existing infrastructural limitations. Again, the government has initiated processes to construct 111 District and Regional level health facilities to bridge the accessibility gap (11). Similar infrastructural improvement efforts such as building hospitals and installing or building oxygen plants are ongoing in countries like Nigeria, Kenya, and Tanzania (12–14).

HEALTH WORKFORCE

The capacity of a nation to deliver adequate health services to its population depends principally on the skills, competence, knowledge, dedication, motivation and deployment of well-trained health professionals (6). However, many countries in SSA lack the adequate human resources (number, distribution, skills-mix) required to deliver essential health services. The inadequacy of human resources in SSA is more exposed since the sub-district recorded its first COVID-19 case. The existing shortage of qualified health professionals to deliver essential services to patients during the pandemic has resulted in the negligence of many essential services such as child and maternal health service delivery, chronic non-communicable diseases (CNCDs), and prevention and treatment of infectious diseases (15). This negligence could be attributed to the fact that the limited health professionals are redeployed into the provision of COVID-19 management services including contact tracing, triaging, laboratory testing and case management services.

There have been some successful responses as well. COVID-19 has, for instance, contributed to improving the skills of health professionals as it has provided opportunities for training and orientation of health professionals in different health service competencies including infection control and prevention protocol, laboratory testing guideline and management of infectious diseases like COVID-19. Regarding the laboratory testing services, the pandemic has contributed to improvements in health technology in SSA. For instance, in Ghana, to deal with lack of laboratory equipment and supplies that delay the COVID-19 testing, Kwame Nkrumah University of Science and Technology (KNUST) and Incas Diagnostics has fast-tracked the urgent development of a rapid diagnostic test kit that is approved by Food and Drug Authority (FDA) of the country for emergency use (16). A similar innovative response is observed in Senegal, which developed its first-ever 3D-printed ventilators and COVID-19 testing kit by Institute Pasteur (17).

HEALTH INFORMATION SYSTEMS

A health information system constitutes a system designed to manage healthcare data. The HIS include collection, storing, managing (analysis and synthesis), transmitting, and converting the data into information and use of clients' medical records for decision making (18). Complete and reliable information is essential for health priority setting and decision-making across all health systems. The data-based health-related decision making underpins the effectiveness of the health system's (hospital) operational management (6). HIS are the foundations of public health in every country especially during a pandemic like COVID-19 (18). Despite the critical role data play in public health decision-making during health emergencies (COVID-19), SSA countries are known to have deficient health information

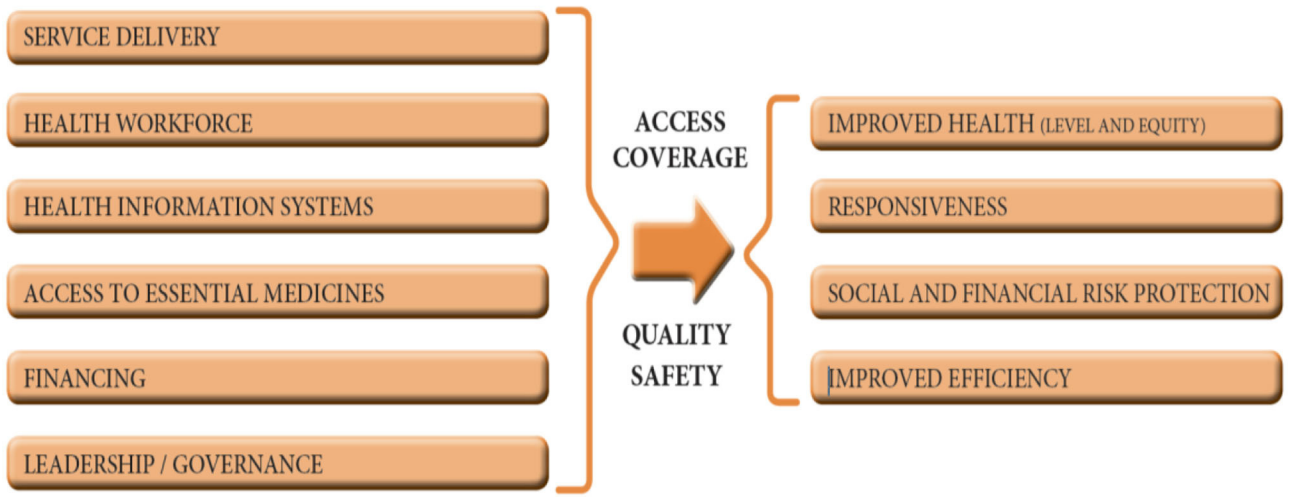

FIGURE 1 | The six building blocks of a health system: aims and desirable attributes. Source: World Health Organization (6).

management systems (19). There are deep discrepancies regarding the COVID-19 "actual" cases reported by the health authorities in SSA. Official COVID-19 statistics, for instance, do not accurately reflect the true cases and deaths reported (20).

Despite the inadequate HIS in SSA even before the pandemic, it is important to indicate some successful responses experienced by SSA regarding the HIS. Some countries in SSA have, for instance, deployed diverse digital information system infrastructures and innovation to increase pandemic communication (daily case updates), contact tracing, tacking vaccination coverage, to effectively manage the COVID-19 and keep the general population informed (21, 22). To respond effectively to the population's demand for regular and timely information on the pandemic, Nigeria, Ethiopia, and South Africa developed a data-driven health information portal with a rapid response component using call centers (21). The response of the public to the call centers in the respective countries was overwhelming. For instance, in South Africa, call center of country's National Public Health Institute (NPHI), the National Institute for Communicable Diseases, received about 146,000 calls in 1 day (23). Similarly, to be able to effectively trace suspected contacts of confirmed cases and prevent further spread of the virus, Ethiopia and Ghana have designed several mobile Apps (COVID-19 tracker mobile app) that trace contact, share data and patient information among the health workers for timely response (24).

HEALTH FINANCING AND ACCESS TO ESSENTIAL MEDICINES

Access to essential health intervention including essential medicines and supplies was already limited in SSA before COVID-19 (22). Some SSA nations experience poor availability of essential medicines in health facilities, frequent stock-outs, substandard treatments, and suboptimal prescription and use of medicines (25). The lack of financial power of SSA countries to invest in health technology, storage facilities for pharmaceutical products and improvements in procurement practices, prove how incapable they are in developing vaccines to fight COVID-19. As such, they become completely dependent on foreign aid for the vaccines as has always been the situation. The persistent health financing constraints in SSA made it difficult for the countries to procure essential medicines to manage COVID-19 cases.

Health financing is fundamental to the effective functioning of health care systems leading to the achievement of the SDGs, including universal health coverage by 2030 (26). Health financing systems in SSA are largely characterized by high out-of-pocket payment, high dependence on external (donor) funding, low government spending and under-developed insurance schemes (21, 26). In 2017, out of pocket health spending was estimated to have exceeded 70% of current health expenditure in Cameroon, Equatorial Guinea, Nigeria and Sudan (27). For instance, foreign funding (donor) of the health system accounts for more than 60% of health expenditure in Mozambique and Malawi (28).

Responding to the inadequacy of financial risk protection in SSA, countries including Ghana, Tanzania, Nigeria, Ethiopia, Kenya, and Rwanda have formulated and implemented national health insurance schemes (29, 30). Despite these efforts, the majority of the population in SSA still suffer financial barriers as out-of-pocket expenditure is required before essential medical care can be delivered, even in emergencies. In such situations, the most vulnerable (poor), therefore, bear the highest burden of diseases and high levels of health expenditure. The already fragile health systems are overburdened with the grave task to address the COVID-19 pandemic. The response to the pandemic which

requires much financial investment from the nations has resulted in low budget allocation to essential health services delivery. This has led to high prevalence rates and preventable death from the pandemic.

Despite the shortfall of the health financing and leadership in SSA during the COVID-19 pandemic, it is also worth pointing out some successful responses that are observed during the pandemic. To effectively mobilize the needed resources to manage the pandemic (public health and clinical care response), diverse resource mobilization was explored, including special COVID-19 response taxes, international grants, cooperate organization donations, political parties fundraising and private citizen donations (31). In Nigeria for instance, the private sector organizations through a coalition known as Coalition against COVID-19 (CACOVID) and Dangote, contributed over US$55.7 million and US$5.1 million, respectively, to COVID-19 response (32).

LEADERSHIP/GOVERNANCE

Poor governance and financial challenges are linked to ineffective integration and delivery of adequate health services in SSA (12). The leadership and management challenges include lack of political will, corruption in health systems, poor resource management. The endemic poor governance in SSA leads to weak institutions and ineffective implementation of health policies, increased healthcare costs, lack of availability and accessibility to health services, reduced efficiency and effectiveness, dissatisfaction among health professionals due to poor motivation, and ultimately poor health outcomes for the population (33). Strong and corruption-free governance is crucial for a robust health system and resilient health system in SSA. However, resources that are mobilized internally by citizens themselves or externally to fight COVID-19 are either mismanaged or diverted to other areas by leadership, leading to inadequate provision of needed medical logistics and supplies such as PPE.

Some governments across SSA have demonstrated political leadership during COVID-19 by establishing several fiscal policies to improve funding of their health systems. These innovative approaches include effective collection of corporate and business taxes and swopping debt reduction for domestic investment in health systems (32). For example, to effectively respond to the pandemic and its economic effects, the government of Nigeria approved US$2.3 million as its fiscal stimulus package. The Government of Ghana also GHc323 million as relief for frontline health workers (32).

CONCLUSION

Long-lasting abysmal health system financing and insufficient government investment in SSA pose major challenges to the effective health service provision amid the COVID-19 pandemic. This situation also makes it difficult for the health system to meet the demands of the COVID-19 pandemic and at the same time, cater for essential services. Despite the constraints faced, interventions introduced by leaders of the various countries induced some resilience among the populace. Countries in SSA must prioritize the reformation of their health systems through effective health system policy development and implementation, human resources development, training, service delivery, governance and regulation, and sustainable health financing. Future studies could also examine the effectiveness of the responses to COVID-19 in sub-Saharan Africa.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

HA conceived the study. HA, RKD, FIS, and JAE wrote the initial draft of the manuscript. LEB and EET provided critical comments which improved the scientific quality of the manuscript. All authors contributed to a review of the initial manuscript draft, gave consent, and approved the final draft of the manuscript for submission.

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Metaphors of War in Effective and Ineffective Coping of Medical Directors of COVID-19 Wards in Public Hospitals

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The COVID-19 pandemic has challenged medical professionals worldwide with an unprecedented need to provide care under conditions of complexity, uncertainty, and danger. These conditions, coupled with the unrelenting stress of overwhelming workloads, exhaustion, and decision-making fatigue, have forced clinicians to generate coping mechanisms. This qualitative study explored the use of metaphors as a coping mechanism by clinical directors of COVID-19 wards in Israeli public general hospitals while they were exposed to death and trauma throughout the pandemic's first wave in Israel (March to June 2020). The study employs discourse methodology and metaphor mapping analysis to capture the personal, organizational, and social dimensions of effective and ineffective processes of coping with an extreme health crisis. Analysis revealed that the metaphors that clinical directors used reflect a dual process of mediating and generating the social construction of meaning and facilitating effective and ineffective coping. Effective coping was facilitated by war metaphors that created a sense of mission and meaningfulness at both the organizational and the individual levels. War metaphors that generated a sense of isolation and sacrifice intensified helplessness and fear, which undermined coping. We propose actionable recommendations to enhance effective coping for individuals and organizations in this ongoing pandemic.

Keywords: COVID-19, coping, clinicians, discourse analysis, hospitals, mapping, social constructivism, war metaphors

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"When the cannons and the corona roar, the muses are silent, and the doctors on the frontline battle against an invisible enemy, in a fog of uncertainty."

BACKGROUND

Health systems and medical staff function under extreme, constantly changing conditions (1). When the COVID-19 pandemic began, there was no treatment protocol or understanding of the medical ramifications. These factors, combined with overwork, fatigue, and intensive exposure to death and trauma, heightened the challenges of working under pressure with staff shortages and insufficient medical equipment (1–3). Doctors and medical teams struggled to cope (4).

While the study of the linguistic, therapeutic, and cognitive mechanisms used by patients to cope with health crises is well-developed, research on the staff's use of linguistic mechanisms for coping with crises is scant (5–7). The current study aims to help fill this gap by examining the use of metaphors and framing of the situation as coping mechanisms used by directors of COVID-19 wards in public hospitals in Israel, upon the outbreak of the pandemic in Israel and throughout its first wave (March–June 2020). This study highlights the effectiveness and ineffectiveness of metaphors in coping with the crises and traumas to which doctors and medical staff were exposed. Understanding the role of metaphors in effective coping may enable the development of intervention programs within the organization. Such staff education may enhance medical teams' coping with stress in both routine work and in crises and may help them build effective coping mechanisms.

The Theoretical Anchor

Conceptual metaphor theory (CMT) is the theoretical framework of this study (8, 9). This theory views metaphors as both a stylistic linguistic phenomenon that describes how we speak and think about one thing in terms of another (10) and as cognitive behavioral phenomena (cognitive arrays) influenced by the individual's socio-cultural experiences. According to CMT (8, 9), metaphors are cognitive structures that conceptualize complex thought by using familiar content worlds drawn from everyday experiences: Concepts from one area (the target area) that the speaker is trying to conceptualize are represented by concepts from an area that is familiar to the speaker from everyday mental and physical experience (the source area). Thus, source areas that are created by everyday experiences serve to conceptualize the target area, which is abstract, difficult, loaded, and unfamiliar (11). An example is the common metaphor *Life is a journey*. The target area is *life*, and the source area that describes and clarifies the target area is *a journey* (12).

Metaphors are generally based on universal experience, but in many senses, they are also culture- and context-dependent. The choice of the source area and its correspondence to the target area are linked to cultural differences between groups (12). Metaphors are a shared cognitive cultural resource and are determined by local culture, discourse, and social elements combined with individual experiences (11–13). Therefore, the analysis of metaphors cannot be separated from their social environment (12).

Metaphors influence cognitive processes and action, in a bidirectional manner. That is, conceptual metaphors and figurative language influence each other in a process that not only reflects thought but also generates thought and action (14). Thus, language is key in social interaction, mediates bidirectionally between recognition and awareness, and frames reality while generating meaning (14, 15). The framing of reality leads to a different view of a given situation and influences human behavior. For example, framing an illness as a war or a journey will shape individuals' view of their illness and their behavior (16).

Conceptual metaphor theory emphasizes metaphors as a shared cognitive resource that shapes cognition and is therefore used frequently in discourse. Combining CMT with the study of metaphors in discourse makes it possible to identify metaphoric structures in discourse and examine their context for those who have the shared metaphorical cognitive-cultural resource that reflects combinations of cognition, feeling, society, and culture. The researcher's work is to recognize the source areas through the discourse as they represent the dynamic use of the language in a given context (17–21).

The Use of Metaphors in Medical Contexts

Health providers, doctors, and medical staff often use metaphors to illustrate medical topics to patients (22, 23). Using metaphors mediates difficult experiences of uncertainty, anxiety, and fear of death. Doctors' use of metaphors has been linked to better relations between doctors and patients (22). Patients diagnosed with various types of cancer have bridged the gaps in understanding and communication by means of metaphors (24), and using metaphors has enabled patients to create order and logic in their world, which had suddenly become chaotic (22, 25). Militaristic metaphors are widely used in the field of medicine by both medical staff and patients (5, 7, 26, 27). War-related expressions such as "attacking" and "the enemy" are common (28). The use of violent military metaphors has occasionally impeded healing by generating antagonism toward the perception of the doctor and of medicine as life-saving (25, 29–31).

Because conceptual metaphors are created and exist on the basis of environment- and culture-dependent individual experiences (12), an analysis of metaphors in the coping processes of ward directors in Israel requires a description of their cultural context.

Israeli Society: The Cultural Background

The Israel Defense Forces are part of the life experience of Israel's citizens, including doctors and medical staff. Military service is compulsory and constitutes a milestone for citizens. Therefore, militarism, military language, and military expressions and metaphors seep into the language, thought, and behavior (32, 33). Studies show the existence of three types of militarism in Israeli society: the aggressive, the cultural, and the cognitive (32). These dimensions can exist separately or in various combinations, so that militarism penetrates to the state of mind both structurally and culturally. Intensive involvement in military action provides a unique natural arena for a thriving war discourse: Normalizing war and militaristic concepts underlies the Israeli discourse (34, 35).

This militarism, which is part and parcel of the Israeli mentality, provides survival as a justification in relation to many topics discussed in Israeli society (36), for example, self-sacrifice, sanctification of death, and the encouragement of childbirth (37). During the COVID-19 period, such language appeared in the media, where it was used to justify and intensify the collection of medical data, epidemiological investigation, and surveillance of citizens (38). In daily life, militaristic metaphors were used also in coverage of the existential threat to Israel's health system, especially by individuals within the system. Health services in Israel are provided mainly by a complex public health system that

receives insufficient government funding. In recent decades the system has also had to contend, in a dynamic, competitive, and changing market, with an ever-stronger private health system. The lack of sufficient funding of the public health system and the attempts to revitalize it have generated a dynamic, turbulent, and threatening environment for health organizations and health system staff (2). During the pandemic period, media coverage and statements by members of the health system extended the narrative of the existential threat to the system by highlighting the distress of the hospitals and the public health system as part of the difficulty of coping with the pandemic. In this sense, the use of militaristic terms by clinicians helped create a sense of cohesion in the face of an external threat and merged with the media expressions of "winning the war" and the "battle against the virus" (36). However, this use of metaphors also served to generate feelings of stress and distress with the aim of pressuring decision makers to adopt policies that would benefit the health system (38).

The current study examines metaphoric linguistic expressions of clinical directors of COVID-19 wards that reflect thoughts, attitudes toward, and perceptions of their experience of directing a ward during the first wave (11, 15, 39).

Analysis of the conceptual metaphors in the directors' attempts to cope with a sudden epidemiological outbreak and an examination of their context at various levels may broaden the existing knowledge regarding metaphors and effective and ineffective coping among medical directors in crises. Therefore, our research questions are: (a) Did the COVID-19 ward directors use figurative language and metaphors during the crisis? (b) What kind of figurative language and metaphors did they use? How did they frame the situation? and (c) How did the use of figurative language shape their coping with situations of crisis and emotional overload?

METHODOLOGY

This qualitative study focuses on an analysis of the discourse in in-depth interviews (20, 21, 40, 41), mapping the source and target metaphors (42) and their positioning in the coping process of ward directors (20, 41).

The Study Population and Data Gathering

Both authors conducted in-depth interviews (45–60 minutes each) digitally via Zoom with 14 of the 21 directors of COVID-19 wards in Israeli hospitals during the pandemic's first wave (March–June, 2020). The data also included a corpus of 21 interviews with directors of COVID-19 wards, which were published in the media at the end of the first wave (June 2020). This corpus provided a reliability check and reinforcement of the findings of the analysis of the main body of data.

All the interviewees agreed to be interviewed and gave written permission for the interview to be recorded and transcribed and for parts of it to be published, on condition of anonymity. The participants were told that they had the right to end the interview at any point. Approval of the study was granted by the ethics committee of the institution with which the first author is affiliated.

The Interviews

At the outset of the interview, the interviewer stated that the purpose of the study was to understand the experiences and thoughts of directors of COVID-19 wards. The interviewer asked one general question: Can you describe your experiences in heading a COVID-19 ward upon, and following, the outbreak of the COVID-19 pandemic? Most of the interviewees needed no clarification and told their stories without hesitation. They were encouraged to tell their stories in their own words, allowing a glimpse of their inner social world and of their experiences as an important repository of the meaning of the story told (43, 44).

The interviews were transcribed immediately in accordance with the rules of transcription. These rules require that the transcriber preserve the discourse precisely by writing down all the words heard in the interview, including hesitations, pauses in speech, and parts of words, and sounds that are expressions of feelings and thoughts—such as laughter, crying, stuttering, and sighing—that might reflect the inner state of the interviewee (43). This type of transcript is used mainly when the researcher is interested in investigating the "what" that is said and "how" it is said (45). The analysis of these interviews and the interviews in the press was conducted in an identical manner.

Analysis of the Findings

The analysis was conducted in three stages. In the first stage, the researchers focused on identifying figurative linguistic means. The identification of a metaphor was conducted in accordance with Schmitt's model: identifying a word or phrase that can be understood beyond its literal meaning by understanding its context, identifying the source area that derives from a physical or cultural experience, and conceptualizing and assigning a source area to a target area (42). An expression is considered metaphorical when its contextual meaning is contrary to, different from, or broader than its literal meaning. Identifying metaphorical constructs that the interviewees generate and determining their source areas makes it possible to preserve their context and affinity to a linguistic construct as it appeared in the interview (18). At a later stage, every metaphorical expression was assigned to a broader concept.

In the second stage, the source areas were assigned to one of three levels—micro, meso, or macro—in accordance with their initial assignments. The micro level included an individual level (in accordance with the individual's characteristics and experience). The meso level was an organizational level (in accordance with the organization's behavior at the managerial, cultural, and financial levels). And the macro level was constructed from the environmental and socio-political context (the nationwide health system and all citizens), as is customary in the analysis of sociological theories.

The researchers resolved disagreements between them by discussing them. Mapping of the source areas and the target areas and assigning them to the micro, meso, and macro levels enabled the creation of a broad picture and an understanding of how the doctors used the source areas to conceptualize their coping with their COVID-19 experiences and their thinking about these processes on the three levels: personal, organizational, and social.

In the third stage, the researchers conducted an analysis of the interviewees in relation to their coping process. Accordingly, source areas were assigned to positive and negative thoughts and positive and negative coping (20, 21, 41). A source area indicating positive thinking was defined as desirable (assigning positive feeling to a new situation), whereas a source area indicating negative thinking was defined as undesirable (negative feeling following an unwelcome change). Positive coping was defined as the interviewees' being active (for example, taking initiative or generating an idea or a plan), whereas negative coping was defined as the interviewees' being activated by external forces over which they had no control—for example, bureaucracy, an unfamiliar virus, or the lack of a protocol (20, 21).

Research Findings

The findings reveal widespread use of military expressions and metaphors, including military analogies and descriptions of military and wartime experiences in both sets of data—the interviews and the published corpus. Other conceptual metaphors or the use of examples from, or comparison to, other areas were relatively rare.

The common use of these metaphors in the media and in everyday discourse, including medical discourse, demonstrates the ever-present awareness of war, which reflects and creates a state of emotional distress and stress at every level.

We're at war against an unknown virus.

> It has the feel of an 8 order [immediate mobilization of the reserves]; everyone is called up, everyone volunteers, everyone helps.

> The wind is a wind of war.

The source areas that were identified were assigned to several topics at the highest level. These topics included the hospital as the site of a battle, the nature of the crisis management, management of the ward, staff, teamwork, dangers and difficulties in contending with uncertainty, planning for the future, and personal topics such as feelings, the perception of cost, and the perception of reward. The source areas were divided in accordance with the micro and meso division—personal or organizational—and the macro division—environmental, political, social, in accordance with the target area and the context. Thus, for example, some areas found expression on two levels and some found expression on only one. This division was made on the basis of elements that have a primary, immediate effect rather than a secondary, long-term effect. Of course, elements that have individual effects and even broad organizational effects also have long-term effects in macro social and economic terms. Thus, for example, topics such as personal price and difficulties that have an immediate effect were assigned to the micro–meso area. However, some of these topics also have a secondary effect in the macro area. For example, such topics as personal sacrifice and difficulties that have an immediate effect at the meso-organizational level were assigned to that level, but some also have a secondary effect at the macro level. Thus, for example, the individual price has ramifications for aspects of cost, work burden, and teamwork, and these aspects have a broad effect not only on the organization itself but also on the entire system at the social and economic level.

All the source areas and target areas are presented in **Table 1**.

The quotations highlight their context in the discourse analysis and the positive or negative interpretation given to them in the context and use of language. The division of the source areas into levels and their influence on framing and cognition were evident in the interviews. Below, we present findings by source areas assigned to all the levels and source areas associated with the micro-personal and meso-organizational level.

Sources Assigned to All the Levels

Doctors identified several source areas as belonging to all the levels. These included broad areas of comparison to war, the analogy of the hospital to a battlefield, the definition of a military state of emergency, and the reward for their efforts, which had personal, organizational, and environmental contexts.

> The days of the corona ward were days of grace. The spotlight was aimed at the front, as in every war, and the front is us. All the resources, all the equipment, all the empathy and sympathy—everything flows toward us.

> The feeling was like that of receiving an immediate call-up order—you get a phone call, you drop everything and come to the meeting point without knowing any more details, but you understand that it's important.

> Everyone is mobilized, everyone volunteers, everyone helps. Everyone was connected, as if it got some kind of prioritization at the national level, and everyone was there.

The use of these analogies enables a feeling of shared destiny, from the national level through the organization itself to the personal level. It is a feeling of belonging to something large, a destiny shared with the country's entire population. Yet, at the same time, there is a differentiation of the medical staff by their comparison to an elite unit, a path-breaking vanguard marching ahead of the troops.

> Internal Medicine C [ward] was created—but outside this whole array, as a general-staff unit, a federal unit.

> The shared work during this critical period created a shared destiny and a feeling of having a mission and of being the medical vanguard. This also gave the other people in the hospital peace of mind.

This comparison enabled the development of esprit de corps, a feeling of uniqueness and of a personal and organizational mission. The staff of the COVID-19 wards received the respect of others in the organization and were accorded priority in meeting the ward's needs. In place of the usual hierarchy based on level of education and position within the hospital, the feeling of the esprit de corps of an elite military unit was created.

TABLE 1 | Main source areas and target areas.

Definition of area	Source area	Target area	Micro individual	Meso organizational	Macro socio-political
Coping with COVID-19 like a war	The hospital as a field of war	Description of what is taking place in the hospital	√	√	√
	A battlefield		√	√	√
	A war front		√	√	√
	A struggle front		√	√	√
	The front is us		√	√	√
A war emergency situation	An emergency order	Feeling of immediate	√	√	√
	An illness that has burst into [our] lives	importance	√	√	√
	A wind of war	Sacrifice	√	√	√
	Immediate call-up [of reserves]	Threat	√	√	√
Managing the crisis	Military/mission-oriented management	Description of management		√	√
	Operations room	Daily description		√	√
	Orders	Organizational order		√	
	Evaluation of the situation	Organizational stability		√	√
	Daily evaluations of the situation			√	
	The hospital in military format			√	
	Army			√	
	Mossad			√	
	Policy evaluations				
Managing the workforce	Recruiting staff Volunteering for this task all hands on deck [sharing the burden]	Description of the process of building a staff array	√	√	
		Work force	√	√	√
		Sense of mission, meaning, friendship, empowerment, feeling of destiny, recognition of importance		√	
The nature of the job	The medical spearhead	Sense of mission	√	√	√
	Vanguard	Importance of the job		√	
	Leading the forces			√	√
The director's roles	The director as an officer		√	√	
	Personal example		√	√	
	The commander's resilience		√	√	
	The corona soldiers		√	√	
The staff's teamwork	The staff's comradeship	Friendship	√	√	
	The staff's cohesion	There is someone to rely on	√	√	
	On the same wavelength Auxiliary forces	Feeling of partnership	√	√	
	Not alone in the battle	Togetherness	√	√	
Cost and difficulties	Alone in the battle	Loneliness	√	√	
	Battle fatigue	Great	√	√	
	PTSD	difficulty	√	√	
	Battling for equipment	Contending with a crisis	√	√	
	Conditions and service	Work conditions	√	√	
Dangers	Running ahead	Paying a personal	√		
	Drawing fire	price	√		
	Exposed on the battlefield	Fear	√		
	Threat to [my] health	Personal sacrifice	√		
Feelings	An invisible enemy	Fear	√		
	Marching ahead in a fog of uncertainty	Anxiety	√		

(Continued)

TABLE 1 | Continued

Definition of area	Source area	Target area	Micro individual	Meso organizational	Macro socio-political
		Helplessness			
		Uncertainty	√		
Reward	Heroism	Meaning	√	√	
	Salute	Respect	√	√	√
	Medal for heroism	Love	√	√	√
	The background behind the wings [a higher level of military decoration]		√	√	√
	Military decoration		√		
	Food shipments arrive		√		
	Esprit de corps		√		

Entry to the ward was managed like a mission and not necessarily according to rank. When a doctor entered the ward, sometimes he was also required to make beds and remove trash.

We also came to value all the "auxiliary forces" of the hospital that worked with great dedication, from the administrative head to the last of the maintenance staff who safeguarded the cleanliness of the department and our lives.

Together with a sense of pride, mission, and the importance of the role, the metaphors revealed feelings of personal sacrifice, self-endangerment, and fear.

There is uncertainty and pressure. Clearly there are concerns, and people are slightly afraid, but in the end, we understood that we're doing something very important that depends largely on the quality of our work.

You try to expose as few staff members as possible, then you go into the ward with a very small rescue force and work a lot harder.

Source areas connected to managing the ward and the staff also found expression at all levels—micro, meso, and macro. Thus, expressions such as "mobilizing the work force", "volunteering for the mission," and "all hands on deck" served to conceptualize the sense of mission, the heightened sense of shared destiny, and recognition of the importance of the role and mission at all three levels as part of the war effort.

I want to thank the ward's staff—medical, nursing, paramedical, and maintenance—and to honor them for mobilizing immediately and getting all hands on deck…despite the fear and panic that were in the air.

Everyone saw the total mobilization, the esprit de corps, and the solidarity of everyone who dealt with the sacred work in this war.

When I was asked to take on the mission of isolating and treating corona patients, it was clear to me that the ward's staff would step up to this mission with full force, precisely because of the sense of mission, of the task, and of marching ahead of the troops.

Source metaphors in the area of management of military operations, such as "operations room," "combat theory commands," and "daily evaluations of the situation," also enabled organizational order, security, and stability at the micro, meso, and macro levels, in parallel to the national level at which the army and other military institutions were helping to manage nonmedical aspects of the crisis.

The hospital's behavior became the behavior of a military unit. We had an evaluation of the situation every day, there was a group of commands…It was very, very helpful.

The hospital prepared itself in a military-like format: daily evaluations of the situation, an operations room, everything was analyzed.

Another source area expressed at all levels was the reward for the actions of the medical staff: recognition of heroism, decorations for heroism, war decorations, and even deliveries of food, generating a sense of pride, gratitude, and respect.

Look at the staff members who continue their devoted work and salute them. They're true heroes.

The places that treated corona received the background behind the wings [a higher level of military decoration], the war decoration.

All the resources, the equipment, the sympathy, and the admiration—it all flows toward us…Every afternoon they also [deliver] the best of Israeli cuisine to pamper the corona soldiers. A euphoric mood, a sudden gentleness in the internal medicine ward, suddenly...the medal of valor [is] on [one's] chest!

Source Areas Associated With the Micro-Personal Level and Meso–Organizational Level

A number of source areas are prompted by, and reflect, micro-meso levels only. They include personal and managerial aspects, some of which are related to the nature of the work and therefore are less relevant to the macro context. An example is the staff's

work. The staff's cohesion is a crucial element in building trust, esprit de corps, and shared destiny, like that in the elite military units in which cohesion is crucial on the battlefield.

> The staff who entered the ward in protective dress knew that they were not alone in the battle. Their colleagues in the team backed them up and watched over them…constantly from the control room, directed and guided their actions. The feeling of solidarity and mutual responsibility increased the trust between the members of the staff.

> When I look in the eyes of the staff members with whom I was on the battlefield…I see a person who is on the same wavelength as me and we understand each other without words.

The feeling of watching out for each other and support by the staff appeared in several metaphors, including the naming of the administrative and paramedical staff members as "auxiliary forces": "All kinds of auxiliary forces including teams that are paramedics"; "Auxiliary forces" of the hospital's administrative teams and others worked with great devotion'.

Source areas that were relevant only to the micro–personal level—such as the price individuals had to pay—were prominent. Expressions such as "running forward in battle," "exposed on the battlefield," "alone in the battle," "battle fatigue," and "post-traumatic stress disorder [PTSD]" shed light on phenomena such as the interviewees' fear, anxiety, and loneliness in battle.

> We all experienced it…when you run ahead into fire,...you're the first one who draws it.

> I'll give you an analogy…It's like battle fatigue.

> A short time before that I saw a series about Chernobyl, and the first few times I felt as though I were in a similar situation facing an invisible enemy. There are no physical feelings of danger, but you are very tense in the wake of reports about the morbidity and mortality of doctors in Italy.

> We learned to march ahead into battle from the battle fog of uncertainty, to rely on intuition, on gut feelings.

The analysis revealed great use of metaphors and examples based on personal experience from the time the doctors were soldiers and officers in the army and in the wars.

> About 200 years ago I was…a crew member on a submarine. So, often …I said to them, "Look, it"s very similar'.

> I remember it also from other wars, from the First Lebanon War and things like that.

> Most of the people here have been in the army. I was in the army for six years. Here that counts as if I'm a total civilian.

The personal war experience shaped the form of management and how the event was perceived also at the experiential level, such as familiar feelings of anxiety, fear, and stress following the outbreak of war. "The corona disease burst into our lives like a storm." "The intensity of the anxiety that I felt for my family, for everyone, is quite similar to the first night of the Gulf War".

At the same time, the wartime experience made it possible to rely on the familiar and the known, which provided a sense of order and organization amid the chaos.

> In Israel, we are militaristic by nature. We all were [in the army], if not sergeants or lieutenant colonels. But yes, the drill is like in a military operation... [Maybe] that was what did the job.

The use of personal military experience is also a by-product of the socio-cultural context in a country in which most of the citizens are former soldiers. To a great extent, even the running of the country is defined by military experience.

> All the behavior was military behavior. All the operations room and the terms, and the army that entered the Ministry of Health, and the Mossad that sat inside the Ministry of Health. And the evaluations of the situation…[all] military concept[s].

The interviewees compared the tasks of managing the ward to the tasks of officers in a war, even though a ward director is normally concerned mainly with medical management. This comparison of the ward director to a commander of an elite unit on the battlefield is not trivial, and it is evidence of the need to enthuse people, to set an example, and to contend with the staff's fear and anxiety.

> The directors were there all the time. The directors went inside; that is, the staff did not feel that they were being sent into the battle without the director shouting "After me!"

> The director has to display this strength. An officer in the army also does this kind of thing.

> It doesn't matter whether you're managing a corona epidemic in a hospital or some elite unit in the army.

> The levels of authority and leadership were higher than the levels of management...In the everyday I'm often just a manager.

These metaphors demonstrate the difficulty of ward directors in a health system with a shortage of job slots, resources, and funds, crowded internal medicine wards, and concern for the daily functioning following the crisis.

> The wonderful but starved health system must be revived, equipped, and strengthened so that it can continue to carry out its professional tasks reliably... both in times of peace and in times of war and epidemics.

> Our elasticity is enormous. We proved it in the lightning war of the coronavirus and we are proving it day by day in the unbearably long war of attrition.

These statements exist alongside the expression of the personal struggle of returning to everyday difficulties.

> We would receive…donations and meals…and attention in the media. Suddenly everything disappeared. You go back to being just another cog in the system and perhaps people now already want to forget you...and that is very, very difficult for some of the people.

Assigning source areas and target areas to the various levels in the world of the interviewees provided a glimpse of their coping mechanisms while demonstrating the difficulties and feelings—the price and the reward, as they saw it—of the state of distress they encountered while trying to contend with and manage the crisis in its beginnings. "And thus, we created the paths of action, on the fly".

Framing the event as a battle, based on past experience and on known terminology while building esprit de corps and cohesion of the staff, enabled coping and construction of a narrative of a mission. "In the end it's how you build esprit de corps, how you build a narrative, how you build the feeling of excellence, of a mission".

Mapping the Interviewees' Modes of Coping and Thought

In the analysis, we mapped metaphorical constructs that were evidence of positive coping and thought and others that were evidence of negative and ineffective thought. Positive coping and thought were defined as the points at which the interviewees positioned themselves as active in the process, initiating, responsible, and instigating, and declared that the process was desirable. The following are examples.

> We're under emergency orders; everyone pitches in to [accomplish] the task.

> A euphoric feeling; suddenly the internal medicine ward is prestigious again.

Ineffective coping, on the other hand, was defined as a process in which the interviewees positioned themselves as passive and activated by forces over which they had no control, such as the pandemic and bureaucracy; experienced stress and tension; and declared the situation as undesirable.

> It's like in war; you want it to be over in a day or two, but it doesn't end.

> [It's]like in the Gulf War and the intensity of the anxiety I felt for my family, like the first night that the missiles were flying.

The source areas and their mapping are presented in **Table 2**.

DISCUSSION

This study analyzed metaphors and their role in framing reality and shaping coping mechanisms among COVID-19 ward directors in Israel during the first wave of the pandemic there. The study makes a number of contributions. Theoretically, it broadens the existing knowledge regarding military metaphors in the discourse between doctors and patients to include metaphors used by doctors in a health crisis. Methodologically, the study analyses the discourse in three stages: identifying source and target areas; assigning metaphors to macro, meso, and micro

TABLE 2 | Source areas and modes of positive and negative coping.

Positive/Negative	Source areas	Micro personal	Meso organizational	Macro socio-political
Use of metaphorical constructs in positive coping	Mobilization and volunteering	√	√	√
	Military management	√	√	
	Auxiliary forces	√	√	
	Vanguard	√	√	
	Elite unit	√	√	
	Personal example	√	√	
	Heroism		√	
Use of metaphorical constructs in positive thinking	Esprit de corps	√	√	√
	Salute	√	√	√
	Pilot's wings	√	√	√
	Medal of valor	√	√	√
Use of metaphorical constructs in negative coping	Invisible enemy	√		
	Marching in the fog of battle	√		
	Fog of uncertainty	√		
	Cost of war	√		
	Exposed on the battlefield	√		
	The first who draws fire	√		
	Battle fatigue	√		
	Battling for equipment	√		
Use of metaphorical constructs in negative thinking	PTSD	√		
	Like an atom bomb	√		

levels; and mapping the interviewees' statements by examining the context and ramifications of effective coping with stressful events. On the practical level, we propose interventions for building effective coping mechanisms for doctors and medical staff in healthcare organizations in times of crisis.

The Use of Metaphors; Source and Target Areas

Doctors who headed COVID-19 wards made extensive use of metaphorical expressions and analogies from the military domain. The military source areas illustrate and mediate the interviewees' cognitive state of war and thus reflected and drove the cognitive framing of the situation. This framing enabled the creation of mechanisms for coping with the sudden distress by drawing on personal and collective experience (8, 9, 12, 13, 17). Thus, for example, the source areas that presented coping with COVID-19 as being like a war included "the hospital as a battlefield". The mediation of the feelings of urgency, emergency, and immediate distress led to the use of metaphors that reflect a state of emergency, such as "emergency order," which generated a feeling of immediate importance, threat, and stress. Framing this situation led to the immediate need to manage the crisis and to the use of military metaphors from this source, such as "military/mission-oriented management" and "operations roo." Such framing enabled the directors to mediate target areas of management and organization that create stability and organizational order.

The directors also used these source areas to mediate managerial roles that were compared to roles of military command—for example, "personal example of the leader." They also expressed the need to manage and consolidate the work force in the wards: "mobilizing a work force" and "fighters' esprit de corps". This framing made it possible to build stability and order while generating motivation and a sense of mission that differentiated the COVID-19 staff as a "medical vanguard" or "elite unit". This was backed up by the great reward, also conceptualized in military terms, such as "war decoration," which also found collective expression, as in the food deliveries and admiration, and connected with the feelings of meaning, respect, and love.

Conceptualizing values that are basic on the battlefield, such as comradeship, cohesion of the unit, and "combatants' esprit de corps," contributed to the feeling of stability, cohesion, and shared destiny of the medical team while drawing on their individual and collective experience. The doctors also presented metaphors from source areas that conceptualize dangers and difficulties, such as "alone in the battle" and "battle fatigue", which reflected and framed distress and difficulty, a high personal price, personal sacrifice, and fear, loneliness, and anxiety.

Framing the Reality in Assigning Micro, Meso, and Macro Levels

The use of metaphors mediated and framed the experience while creating meaning and logic (7). Assigning the source areas to three levels makes it possible to examine the framing and creation of the cognitive reality as the interviewees saw it. The micro level is composed of the personal level, which includes the individuals and their characteristics, personal experiences, and immediate environment. The meso (organizational) level includes the organization in which they work and their organizational culture. The macro level includes the socio-political complex of the state. This level is greatly affected by processes and perceptions at the individual and organizational levels. In the long term, framing reality and perceptions at the individual and organizational levels will also indirectly affect the macro level—the environment and the decision makers in it.

In Israel, from the start, the pandemic was described in military terms, including "war" and "nationwide mobilization" (46, 47). The use of bellicose metaphors by journalists and politicians became a tool for enlisting civilian cooperation in many countries (48). Similarly, in Israel, positioning doctors as combatants in the vanguard of the struggle enabled the use of concepts of the heroism of the vanguard in an elite unit. This, in turn, helped create a narrative of having a mission, importance, and personal and organizational meaning, accompanied by admiration of the public and the media. This framing of the situation created a sense of comradeship and individual and collective empowerment, which enabled acceptance of the price of working in COVID-19 wards. However, excessive use of the narrative of heroism should be avoided, because it could have a negative psychological effect on health system staff and might make it difficult for them to define the limits of their obligation to provide medical treatment (49).

The source areas that created a feeling of having a mission, motivation, order, and organization of the work force took on a broader application on all levels. They intensified the feeling of emergency, shared destiny, the need to act immediately, mobilizing a work force, and managing it, and resulted in expressions of great admiration for the COVID-19 staff. But assigning the source areas that mediated experiences and feelings of fear and of personal cost only to the personal level emphasized the sense of isolation, which was evident also in the distancing from family members and colleagues and thus intensified the feeling of being alone in the battle. This was true also of feelings of fear, anxiety, and isolation as part of the price they paid.

These findings support previous studies that viewed the use of metaphors as a double process (14, 15) and their use to construct the situation as motivated by contexts at the macro and micro levels and influenced by personality, life experience, and cultural characteristics (12, 13).

Effective and Ineffective Coping Mechanisms

The use of metaphors that had a positive impact enabled effective coping with a complex reality. Metaphors that had negative contexts constituted ineffective mechanisms of coping. The war metaphors that promoted effective coping created a sense of order and coherence, like the reality-construction and sensemaking processes in

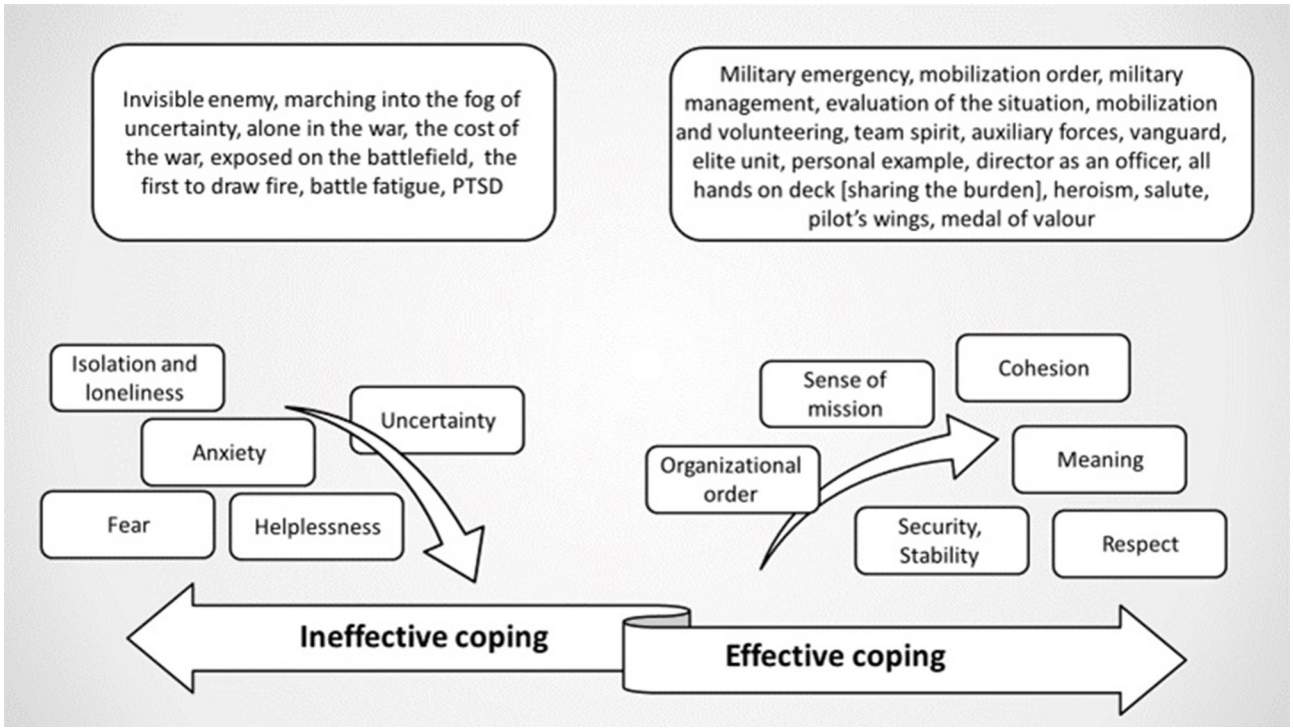

FIGURE 1 | Effective and ineffective coping mechanisms.

understanding the environment through order and logic based on past experience (50). Managing in accordance with orderly rules and a clear daily routine enabled a reframing of the chaotic reality according to familiar patterns (51).

In contrast, military metaphors such as "battle fog," and "loneliness in battle," reflected, generated, and intensified feelings of isolation and loneliness, helplessness, uncertainty, and sacrifice, and contributed to intense feelings of being stuck and fear among some interviewees. Just as doctors' use of military metaphors that are linked to traumatic experiences of difficulty and isolation on the battlefield may generate antagonism in some patients, so such metaphors may arouse in the staff a framing of the situation that matches those experiences (5, 47). The extensive use of military metaphors may generate panic, paternalism, reduced effectiveness of coping, and resistance to cooperation among the public, and in the case of COVID-19 might lead to increased hospitalization of patients (5, 23). The ramifications of the use of military metaphors for framing a situation vary from person to person (7, 23). Also, the ramifications of the use of these metaphors by the medical staff may have a deleterious effect on the doctor, depending on the doctor's personality. Therefore, although the use of such language can be a powerful tool, its limitations and its effects on environmental and personality factors should be kept in mind. Allowance should be made for alternative metaphors so that an optimal fit can be found for the individual and the environment (23).

Figure 1 shows the influence of the use of military metaphors and images on the contexts at the various levels.

CONCLUSIONS AND RECOMMENDATIONS

At the macro level, in Israel, as in other countries, the COVID-19 pandemic has been defined in militaristic terms in the political, public, and media discourse (46, 47). This broad use of such terms, as part of a siege mentality (36), has served as a means of maneuvering individuals toward cohesion and shared effort. The siege mentality is characteristic of Israel, whose population is experienced in drawing together against an external enemy. The use of such metaphors at various levels, cultural and cognitive, is characteristic of the Israeli mindset and narrative: The entire system is oriented, both organizationally (economically, industrially, and constitutionally) and mentally, toward constant preparation for war, as if this were the natural state of the world (32). Therefore, the use of such language in the general discourse, together with the use of such expressions in describing the health system in its entirety and the coping of the medical teams in particular, reinforced this mentality and made it possible to frame the situation as a battle against a common enemy. This framing helped reduce public criticism of the failures in managing and financing the crisis (46). It also achieved the public's cooperation in such health matters as quarantines and epidemiological monitoring (36, 52). The health

system, from a sense of emergency, made media and political use of this militarism to float and justify previous broad demands, such as additional staff positions and funding for the health system, and justified and intensified criticism of the state policy of underfunding the health system.

At the micro–individual and meso–organizational levels, the use of this militarism relied on the individual experience of the members of the medical teams as part of the process of effective and ineffective individual and organizational coping. Undoubtedly, these processes preserved militarism at all levels in Israel and in this case made possible systemic coping with the COVID-19 crisis. However, these processes at the political level may lead to silencing of criticism of managerial and political behavior, which is an important aspect of democracy and making the system more efficient. At the personal and organizational levels, too, the use of metaphoric discourse and the inculcation of such values and principles as part of the discourse culture and of the organization is important, with the proviso that there be recognition of the limitations of this tool, which differ from person to person and are also influenced by the organizational context (23). Therefore, the use of such discourse must be accompanied by organizational, managerial, and even economic changes, such as emotional and financial support and concern, both at the organizational level and at the level of decision makers. These changes will strengthen the system and will reflect these empowering and strengthening values and perceptions under everyday conditions and in times of crisis.

To generate more effective coping among medical personnel and organizations in coping with crises, we propose using metaphors, analogies, and words that emphasize ideology and values that empower (heroism, cohesion, comradeship). We also propose avoiding metaphors, analogies, and words that emphasize distress and isolation (53). Sharing beliefs and values through selected metaphors, adapted to the individual in a given cultural context, may contribute to effective coping of doctors in a crisis by reframing the situation. Adopting metaphors that emphasize the meaning of the role and the importance of individuals and their actions—in addition to appreciation for their contribution to the organization—is essential for effective coping that motivates the individual and increases willingness to pay the personal, familial, and societal price. Integrating these values-laden expressions in the organizational discourse as part of the array of coping patterns may make it easier for individuals to reframe a complex reality.

Inculcating values and regulations that generate stability, such as leadership and planning, together with crisis-oriented leadership training of staff, can shape the perception of stability even in a crisis. Using these values as anchors in everyday situations may help increase the emotional wellbeing of ward directors and staff while fostering optimal functioning of the individual and the organization.

Using metaphors in the organizational discourse may reduce the staff's feelings of isolation and personal sacrifice and may contribute to the construction of an array of supportive defense mechanisms for everyday conditions and crises. It may also prevent destabilization and less effective coping in crisis situations. The contribution of military metaphors that emphasize staff cohesion, training, comradeship, and partnership cannot be overstated. Using metaphorical discourse and funding activities aimed at generating cohesion through such discourse are crucial for clinicians' wellbeing and for their optimal functioning.

DATA AVAILABILITY STATEMENT

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

ETHICS STATEMENT

The studies involving human participants were reviewed and approved by Hadassah Academic College. The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LN-S: conceptualization, data curation, methodology, writing-original draft preparation, writing-reviewing, and editing. GG: conceptualization, data curation, writing-original draft preparation, writing-reviewing, and editing. All authors read and approved the final manuscript.

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Leadership During a Pandemic: A Lexical Analysis

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To manage pandemics, like COVID-19, leadership can enable health services to weather the storm. Yet there is limited clarity on how leadership manifested and was discussed in the literature during COVID-19. This can have considerable public health implications given the importance of leadership in the health sector. This article addresses this missed opportunity by examining the literature on leadership during a pandemic. Following a systematic search of nine academic databases in May 2021, 1,747 publications were screened. Following this, a lexical analysis of the results section was conducted, sourced from a corpus of publications across myriad journals. The results found a prevalence of references to "leader" as a sole actor, risking the perpetuation of a view that critical decisions emanate from a singular source. Moreover, "leadership" was a concept disconnected from the fray of frontline workers, patients, and teams. This suggests a strong need for more diverse vocabularies and conceptions that reflect the "messiness" of leadership as it takes shape in relation to the challenges and uncertainties of COVID-19. There is a considerable opportunity to advance scholarship on leadership via further empirical studies that help to clarify different approaches to lead teams and organizations during a pandemic.

Keywords: leadership, COVID-19, health service management, Leximancer, review

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INTRODUCTION

When the World Health Organization (WHO) declared a public health emergency of global concern on March 11, 2020 (1), there were few precedents for the multiple social, economic, and institutional impacts that this pandemic would generate. The need for capable, resilient leaders with strong adaptive capacity would appear to have never been more important. This is particularly the case in the health sector, where the challenges and uncertainty surrounding COVID-19 are magnified (2).

Despite the importance of leadership in the health sector (3–5), there is limited clarity on how leadership manifested and was discussed in the literature during COVID-19. This represents a missed opportunity to learn from recent experiences, particular given the likelihood of future pandemics (6–8). To address this gap, this article examines leadership research pertaining to COVID-19.

Through a lexical analysis of 36 publications, this article offers a snapshot of how leadership, as a concept and practice, was characterized. While the results reveal pathways within the discourse where leadership was demonstrated, experienced, or longed for during the global crisis, they also reveal fertile ground for future research.

METHODS

A search strategy was deployed in nine academic databases in May 2021 to identify all publications on leadership during COVID-19. Given their relevance and comprehensiveness, the following academic databases were included: APA PsycArticles; APA PsycInfo; Business Source Complete; CINAHL Plus with Full Text; Health Business Elite; Health Source: Nursing/Academic Edition; Medline; Psychology and Behavioral Sciences Collection; and SocINDEX with Full Text. The search strategy encompassed leade* and terms that denote COVID-19 (i.e., coronavirus, COVID-19, pandemic, or SARS-CoV-2) within the title and/or abstract of the publication to optimize the relevance of each publication. Alternative terms that potentially denote leadership were purposely absent from the search strategy to optimize coherence—for instance, although the terms, management, administration, supervision, and authority, might be relevant, they are not synonymous with leadership—as such, they did not form part of the search strategy to optimize comparability among the publications that were identified. Publications were included in this review if they: pertained to COVID-19; were published in English; represented an empirical study (regardless of whether it involved the analysis of primary or secondary data), rather than a literature review (including systematic reviews and meta-analyses), a conceptual study, a discursive article, a study protocol, an editorial, a commentary, or a book review; were authored; and represented a refereed journal publication. This study purposely focused on empirical studies, irrespective of research design, to clarify patterns in academic discourse on how leadership was portrayed – as such, gray literature and policies were not included in this lexical analysis.

Of the 2,377 publications identified via the aforesaid academic databases, 40 met the aforesaid criteria (see **Figure 1**). To optimize robustness: both authors screened the first 55 publications by reviewing the title and abstract of each identified publication to determine whether it met the aforesaid criteria; discussed their selections; and reconciled differences. Following this, each author screened half of the remaining publications by reviewing the title and abstract of each identified publication to determine whether it met the aforesaid criteria ($n = 1{,}692$) and conferred about those that warranted discussion. Of the 40 publications deemed to be eligible, 4 were inaccessible and were omitted from the analysis—thus, 36 publications were included in this review. The results section from each publication was then sourced and prepared for a lexical analysis—this involved copying and pasting the text (excluding tables and figures) into a single Word file. Focusing solely on the results section of each publication helped to ensure the lexical analysis was not diluted by potentially redundant text (e.g., a review of extant literature, a description of the methods used, a discussion of implications for others and methodological limitations).

Of the 36 publications, most were published in 2021 (61.1%), rather than 2020 (38.9%), and most presented a study conducted on one continent (86.1%)—chiefly, North America (47.2%). Other continents represented included: Europe (19.4%); Asia (13.9%); Oceania (2.8%); and Africa (2.8%). Several publications reported on a study that was conducted in more than one nation (13.9%). The publications were published in journals pertaining to several different disciplines, including: management (41.7%); healthcare (38.9%); psychology (16.7%); and, to a lesser extent, education (2.8%).

To optimize the likelihood of a systematic approach (9), the lexical analysis was aided by Leximancer—data-mining software that uses Bayesian reasoning to detect key concepts and reveal their relationships (10). Using algorithms, Leximancer identifies frequently occurring and co-occurring words and amalgamates these to form and visually map concepts that reflect themes within the text (11). The maps convey three types of information—"the main concepts in the text and their relative importance; the strengths of links between concepts (how often they co-occur); and similarities in contexts where links occur" (12). Concepts represent "collections of words that generally travel together throughout the text" (13). The components of these concepts are ordered within a thesaurus, comprised of relevant words and weightings to indicate relative importance. Within the map, connections between concepts that are most probable are represented by a spanning tree of gray lines or branches. Clusters of concepts within a map—known as themes—suggest contextual similarity (14). Themes are color-coded to signify those that are (not) important, whereby the "most important theme appears in red, and the next hottest in orange, and so on according to the color wheel" (13).

Leximancer was used in three steps. First, after uploading the Word file into Leximancer, the "discovery" mode was used to, "see what concepts were automatically generated by Leximancer without intervention" (15). Second, Leximancer was used to examine the comparative importance of the concepts, as denoted by relevance percentage. A relevance percentage represents "the percentage frequency of text segments which are coded with that concept, relative to the frequency of the most frequent concept in the list… This measure is an indicator of the relative strength of a concept's frequency of occurrence" (16). Third, the branches that connected concepts germane to this study—namely, *leadership* and *COVID*—were examined.

RESULTS

The concept map at 70% theme visibility and the accompanying thematic summary reveal four themes—namely: *COVID*, *significant*, *work*, and *countries* (see **Figure 2**). These highlight the key clusters of concepts represented within the text. Theme position illustrates the relationships between the themes. Consider the prominence and centrality of *COVID*, which appears in red and overlaps with the remaining three themes. Given that all the publications focused on COVID-19, the prominence of this theme is unsurprising. Its overlap with the remaining themes suggests that, when the publications referred to *COVID* (and the concepts therein), they were inclined to refer to *significant*, *work*, and *countries* (and the concepts therein):

> The command center began a daily outreach via email for up-to-date information to all employees on system-wide **COVID**-19 efforts. Nursing leaders augmented their

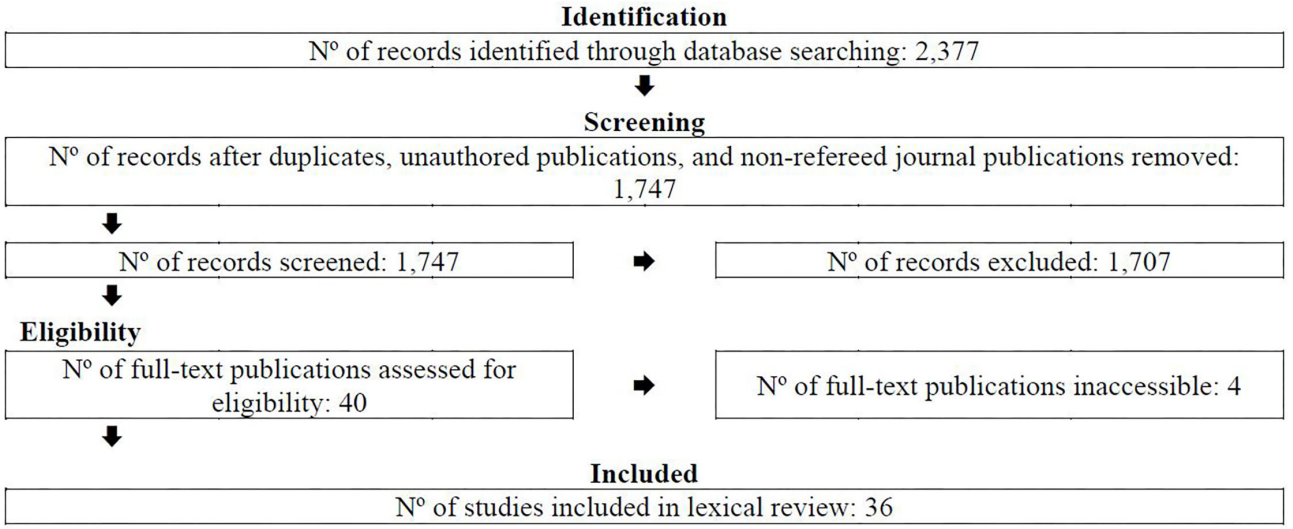

FIGURE 1 | PRISMA flowchart.

> **work** schedules to increase visibility and support [(17); emphasis added].
> It is her ability to communicate purpose to the people of her country in a clear and frequent manner. This can be seen by citizens of New Zealand, such as Christine Nam who said, "Most New Zealanders can verbalize the government's response to **Covid**-19, while the same can't be said for other **countries** because the response has been muddled and indecisive" (Taylor 2020, p. 2) [(18); emphasis added].

While the centrality of the theme, *COVID*, is noteworthy, so too is the distance between the themes, *work* and *countries*. This suggests that when the publications referred to *work* and the concepts therein, like *project*, they were disinclined to refer to *countries* and the concepts therein, like *China*, and vice versa:

> The interactions between **work** conditions and communality significantly predicted competence, such that high ratings of communality led to higher competence evaluations for the **work** from home group than the other two groups (see Supplementary Figure 1). However, the interactions between **work** conditions and agency did not predict competence [(19); emphasis added].
> In 2017, Forbes reported that China now owns international port holdings in Greece, Myanmar, Israel, Djibouti, Morocco, Spain, Italy, Belgium, Cote d'Ivoire, Egypt, and about a dozen other countries 66. In 2018, China took control of Kenya's largest port after that nation defaulted on its unpaid Chinese loans [(20); emphasis added].

Given the focus of this study, three concepts warrant closer consideration—namely, *leader*, *leadership*, and *leaders*. Although *leader* and *leadership* are in close proximity to each other, *leaders* is not. This suggests that, while references to *leader* were likely to travel with references to *leadership* (and vice versa), references to *leaders* were less likely to travel with either of these concepts:

> While an effective **leader** may not always be an effective manager, the group members agreed that an effective manager should always be able to display effective **leadership** skills [(21); emphasis added].
> Frontline administrative **leaders** spearheaded the charge against the COVID-19 with vigor but soon lost tempo due to unfavorable circumstances and preferred to remain in the shadows. Central administrative **leaders** are widely believed to be calling the shots, but they, too, remain largely out of sight [(22); emphasis added].

Furthermore, relative to the concepts, *leader* and *leadership*, the concept, *leaders*, is in closer proximity to that of, *COVID*. As such, discourse pertaining to the pandemic was likely to travel with discourse pertaining to *leaders*, plural, rather than that pertaining to a single leader or leadership:

> Nurse **leaders** face a tough road ahead as health care providers grapple with a pandemic. While non-health care workers begin to seek a new normal, the script has not changed for nurses who go to work every day to treat and care for **COVID**-19 patients [(23); emphasis added].
> And one of my jobs as a **leader** is to give them their heads, it's a matter of identifying where the strengths are and evolving them. (George) I was really impressed, surprised, overwhelmed by the leadership of our senior leadership team [(24); emphasis added].

Given the important relationship between leadership and followership (25–27), it is curious to note that the concepts, *leader*, *leadership*, and *leaders* are not closely coupled with the concepts, *team*, *members*, or *others*. They are not in close proximity, nor are they directly connected. Similarly, *leader*, *leadership*, and *leaders* are not closely coupled with *nurses*,

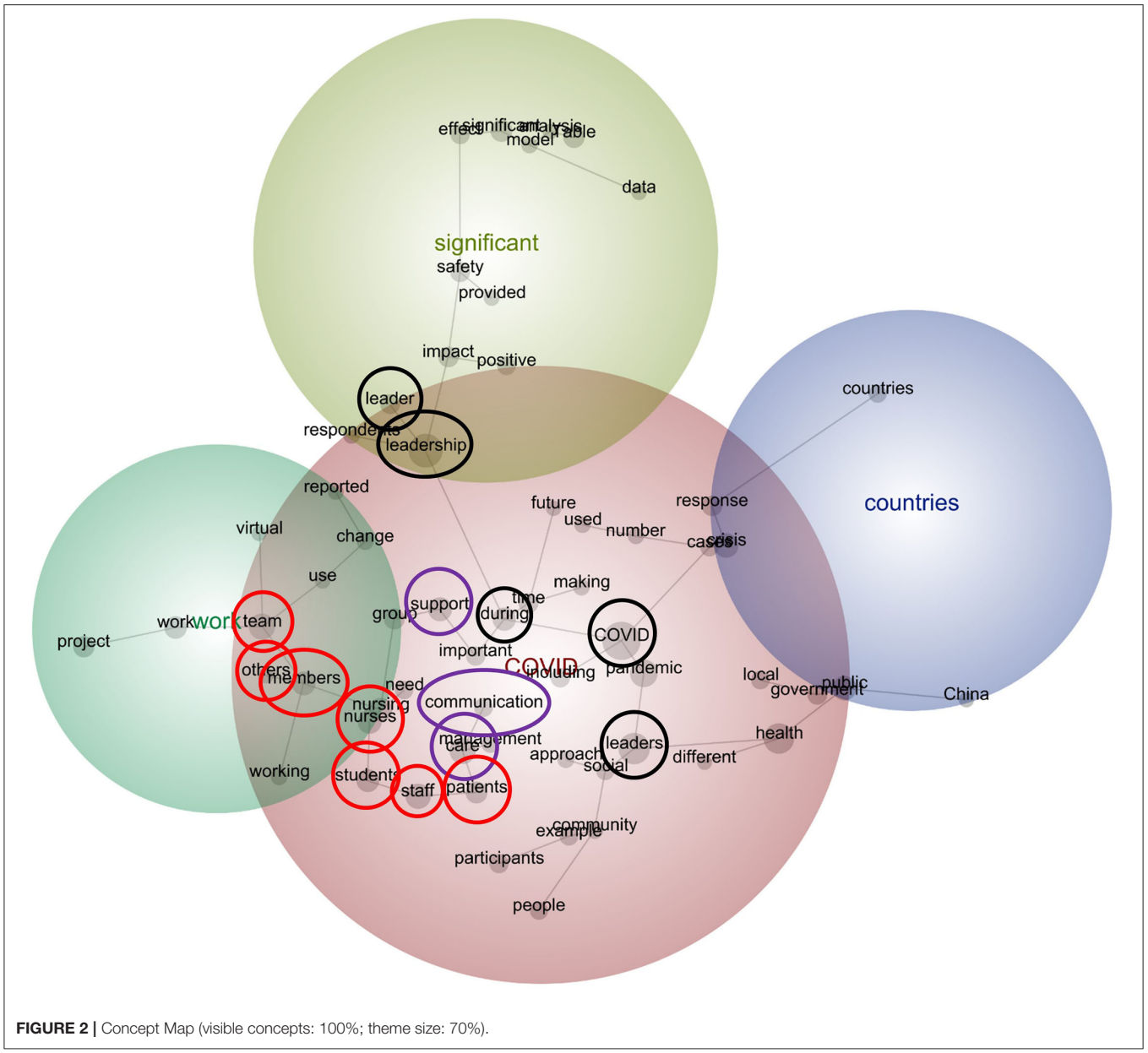

FIGURE 2 | Concept Map (visible concepts: 100%; theme size: 70%).

students, *staff*, or *patients*. Collectively, these findings suggest that discourse pertaining to leadership did not typically travel with discourse pertaining to these cohorts:

> They are made of **team members** who are perseverant and highly motivated. Koser et al. also find that, with these teams, performance is not enhanced by the equipment [(28); emphasis added].
>
> However, many **nurses** reacted positively to this new reality: they strengthened their knowledge base and devised new solutions. Nevertheless, the pandemic has left deep marks in the professional lives of many **nurses** [(29); emphasis added].

Also curious is the position of the concepts, *support*, *communication*, and *care*. Although effective leaders are touted for their supportive, communicative, and/or caring style, particularly during times of change and uncertainty (30–33), these concepts are not closely coupled with *leader*, *leadership*, and *leaders*. As such, discourse from the publication results that pertained to leadership did not travel closely with discourse pertaining to support, communication, or care (and vice versa):

> Previous pandemics have demonstrated the essential role that crisis **communication** plays in building trust and solidifying the perceived legitimacy of public leaders (Siegrist and Zingg, 2014). In Chile, effective **communication** has been an issue during the pandemic [(34); emphasis added].
>
> For example, if the primary problem had been defined as hospitalizations, and deaths as the consequences, then we might have limited our countermeasures to increasing hospital bed and

TABLE 1 | Top four ranked concepts.

Concept	Count	Relevance (%)
Name-like concept		
COVID	203	100
Word-like concepts		
Leadership	159	78
Leaders	159	78
Health	147	72

> intensive **care** unit surge capacity as the primary strategy to save lives. In contrast, with a public health prevention mindset, we defined the problem as uncontrolled community transmission of SARS-CoV-2, with the consequences being the number of cases, hospitalizations, and deaths [(35); emphasis added].

Of all the word-like concepts—that is, the concepts that do not denote proper nouns, like *COVID*, *Table*, and *China*, all of which commence with a capital letter—*leadership* and *leaders* have the greatest relevancy score (see **Table 1**). Specifically, the concepts, *leadership* and *leaders*, are both 78% relevant to that of *COVID*, which is the most salient (100%):

> It appears, therefore, that Germany under Merkel's **leadership** will continue to consider **COVID**-19 to be a serious threat for the foreseeable future [(36); emphasis added].
>
> As noted in the method section, 84% of our participants are **leaders** at institutions that had crisis management plans. Yet, our leaders agreed that these plans were not as helpful as they could be for **COVID**-19 [(37); emphasis added].

The connection between the concepts, *leadership* and *COVID*, is indirect, with the concept, *during*, serving as a nexus between the two, as indicated by the branches. This demonstrates a pathway within the discourse, whereby it was through the global crisis that leadership was demonstrated, experienced, or longed for:

> I learned that I needed to LISTEN to my frontline and provide them with the support and trust **during** these difficult times (NE03). Our success in dealing with **COVID**-19 resulted from the flexibility of the nursing leadership in being leaders and being followers [(38); emphasis added].

Collectively, these findings suggest that, although all the publications met the inclusion criteria, discourse pertaining to leadership was not coupled with indications typically associated with leadership. This helicopter view of the publication results suggests that references to leadership in the context of COVID-19 did not travel with references to collaboration with or serving others—nor did they travel with discourse on support, communication, and care.

DISCUSSION

To manage pandemics, leadership can enable health services to weather the storm. Yet there is limited clarity on how leadership manifested and was discussed in the literature during COVID-19. This can have considerable public health implications given the importance of leadership in the health sector (3–5).

To address this missed opportunity, a lexical analysis was conducted of the results section of relevant publications, identified via a systematic review of nine academic databases. From this, two key findings were revealed. First, among the publications included in this study, *leadership* discourse was often associated with a single *leader*, rather than multiple *leaders*—this is despite the demonstrated relationship between *leaders* and *COVID*, as per the concept map. This reinforces the way in which leadership is often attributed to an individual, rather than to a team of leaders (39).

Second, and related to the previous finding, discourse pertaining to leadership was not closely connected with that pertaining to others. The ways in which leaders and leadership were described were somewhat disconnected from other stakeholders, including colleagues and patients, and relationships with these stakeholders. Consider the separation between the concepts relevant to leaders(ship) and those relevant to particular cohorts—similarly, consider the distance between the concepts relevant to leaders(ship) and the concepts, *support*, *communication*, and *care*.

Collectively, these findings potentially signal a problem with the ways in which leadership during a pandemic is conceived. Specially, the emerging discourse on COVID-19 appears to place an incredible onus on sole individuals who are unlikely to meet the varied expectations of themselves and others. This can unhelpfully fortify the "cult of leadership" (40).

Progressive understandings of leadership recognize the concept as relational and one of many ways to organize, akin to a "Swiss army knife" (41, 42). For instance, Alvesson and Blom (43) noted that a myopic view of leadership does little to advance its scholarship and practice:

> In contrast to many other popular texts on how to "lead" an organization, our suggestion is to move away from a one-sided focus on the manager (as a potential leader) knowing best and viewing leadership as the ultimate key driver, making all the key decisions, including if and how to delegate. Wise forms of organizing need to involve also the non-managers… we emphasize the importance of initiatives from and dialogue with the subordinates… to define and agree upon the appropriate balance between… different modes [of organizing].

Furthermore, these authors argued that continued references to leadership can unhelpfully reinforce an unsophisticated assumption that it is the panacea for organizational woes:

> We also, in contrast to most writings on leadership, deliberately use alternative vocabulary to leadership… to address various options… this helps managers and others break away from being trapped in narrow-minded, leadership-infused language and thinking. We strongly warn against the over-use of the

> term "leadership"… If we look at virtually all leadership and management literatures and listen to the large majority of managers and management educators there is a strong and often naïve belief… that "leaders rule and lead followers." We need to support alternative vocabularies and mind-sets… Our suggestion [is] to see leadership as just one option and to emphasize both a range of alternatives, and the need to include subordinates in the active work of finding a good combination of alternatives… leadership recipes are attractive and seductive, but [are] seldom… helpful… We have studied many managers creating problems for themselves through a naïve and uncritical belief in seductive leadership ideals (43).

Given the findings from the lexical analysis, the emerging literature on leadership during COVID-19 would benefit from more varied vocabularies and conceptions that reflect the "messiness" of leadership (44). Without this, researchers risk the prospect of promulgating unhelpful scholarship.

Despite the value of the findings presented in this article, four methodological limitations warrant mention. First, the search strategy is unlikely to have identified all relevant articles, given the many potential ways to refer to the key terms (i.e., leadership, pandemic). Second, given the sole use of a lexical analysis, a thematic or critical analysis of the publications is likely to yield different findings. Third, given the study period, the lexical analysis was unlikely to include studies that serve to identify the longer-term effects associated with particular leadership approaches. And fourth, the geographical scope of the publications represented in this study directed attention to better-resourced nations. There is therefore no assumption that the findings have relevance to all nations or continents.

Notwithstanding the aforesaid limitations, a key strength of this study is the use of a lexical analysis to ascertain patterns in academic discourse on leadership during COVID-19. For three key reasons, using Leximancer can be particularly useful during a global pandemic. First, it can simultaneously make sense of "voluminous and disparate bodies of texts" (45)—this benefit is noteworthy, given the exponential growth of the myriad forms and sources of information pertaining to COVID-19, some of which was conflicting. Second, by providing a helicopter view of the discourse, Leximancer can elucidate patterns in how language is used (46)—this can serve to compare different forms and sources of discourse, as well as gauge changes overtime in perception, sentiment, tone, and content. For instance, there is opportunity to test public perceptions and the effects of policy changes using, for instance, a large corpus of media reports, social media, and public health reports. Third, because of the algorithms Leximancer uses, its analyses are less researcher-driven, relative to other approaches, like thematic analysis (47)—this offers a more objective interpretation, reducing the introduction of bias based on assumptions. Given these affordances, lexical analyses using Leximancer can inform research and policymaking, particularly during precarious periods, like a global pandemic.

The findings from this article have clear implications for scholars. Beyond the oft-cited call for more research, what is particularly needed is research that is empirical. This is because, of the 1,707 publications that were excluded from this study, many were: commentaries; conceptual and rhetorical analyses of the performance of political leaders; personal accounts of COVID-19 experiences; or reflections on the leadership of those on the frontline (29, 48–53). This suggests there is considerable opportunity for empirical research, particularly that which will help to clarify different approaches to lead teams and organizations during a pandemic. Additionally, given Alvesson and Blom's (43) advice, research is needed that provocatively draws on diverse vocabularies and conceptions of managing and leading. Rather than continue to situate leadership on select individuals, the time is ripe to problematize, critique, and advance the scholarship and practice of leadership (54, 55).

AUTHOR CONTRIBUTIONS

AD conceived the study design, deployed the search strategy, and developed the Sections titled, Methods and Results. AD and AM designed the study as well as developed and tested the search strategy, reviewed the identified publications, identified those that met the inclusion criteria, as well as extracted and analyzed content from the relevant publications. AM developed the Sections titled, Introduction and Discussion. All authors have agreed to be personally accountable for their contributions and ensure that questions related to the accuracy or integrity of any part of the work, even ones they were not personally involved, are appropriately investigated, resolved, and the resolution documented in the literature, and reviewed and approved the final manuscript.

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Development Work in Swedish Eldercare: Resources for Trustworthy, Integrated Managerial Work During the COVID-19 Pandemic

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The extensive needs for developments of eldercare addressing working conditions, care quality, influence, and safety was highlighted during the pandemic. This mixed-method study contribute with knowledge about capability-strengthening development work and its importance for trustworthy managerial work, before and during the COVID-19 pandemic. Questionnaire data and narratives from first-line managers immediately before (n = 284) and 16 months into the pandemic (n = 189), structured interviews with development leaders (n = 25), and documents were analyzed. The results identify different focuses of development work. Strategic-level development leaders focused the strengthening of old adults' capabilities. While operational-level leaders approached strengthening employees' capability. First-line managers' rating of their trustworthy managerial work decreased during the pandemic and was associated with their workload, development support and capability-strengthening projects focusing employees' resources. The study demonstrates the gap between strategic and the operational levels regarding understanding of capability set and needed resources for strengthening capabilities and trustworthy, integrated managerial work regarding safety, influence, and quality conditions for old adults and employees.

Keywords: change leadership, home care service, capability, managerial work practice, leadership, elder care, organizational improvement, organizational developments

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INTRODUCTION

In Sweden and globally, current and future demographic data clearly indicate a growing population of older citizens in need of eldercare, combined with a smaller population of younger citizens in the labor market. The need for sustainable reform and organizational development that is both reliable and manage to maintain or strengthen the capabilities of the old adults, employees, and eldercare organizations has accordingly been advocated for several decades (1, 2). The COVID-19 pandemic has emphasized this need by exposing the insufficient resources allocated to eldercare and the poor trustworthiness in terms of poor quality, safety, and working conditions, as well as lack of influence among the old adults and employees (3). This study identifies the focus of and conditions for ongoing development work at the strategic and operational levels, noting the importance of this work for trustworthy operational management work.

Strengthening Individual and Organizational Capabilities in Eldercare

The capability approach (4, 5) refers to the ability and resources needed to live a life and work in a way one values, and to the conditions that strengthen that ability. An individual's capability is determined by his or her access to the resources and ability needed to convert resources into personal goals (5). Organizational capability refers to an organization's ability to implement management practices based on its resources and preferences (6). Resources may refer to general and specific conditions and to organizations' management strategies. The configurations of resources determine the frame of opportunities available to realize chosen goals. The concept thus offers an analytical tool with which to understand the conditions determining individuals' and organizations' ability to realize goals by converting resources.

A capability approach to eldercare is vital if we are to understand how the way we organize and strengthen the conditions of eldercare promotes the opportunity to realize the preferences and values of the old adults, employees, and the eldercare organization. This refers to the conditions determining: (a) old people's capability to use their resources to make choices about their living conditions; (b) employees' capability to use their resources at work; and (c) the organization's capability to implement its strategies and provide good service during crises.

Capability-strengthening development projects may have different focus, grounds and conditions. The strengthening of *older adults*' *capabilities*, which addresses their opportunities to influence and participate in decisions concerning their lives, is regulated by law in Sweden. However, using opportunities of capabilities require influence over every-day decisions, abilities and skills, e.g. eHealth literacy (7). The strengthening of *employees*' *capabilities* addresses their working conditions and the resources needed to conduct their work, such as influence, competence, and health. This strengthening is needed, with or without a pandemic situation, since eldercare employees frequently face higher risk exposures in their working environment, experience more occupational disorders, take more sick leave, and display earlier retirement behavior (1). While employees in other sectors in Sweden have recently faced decreased work demands (8), eldercare work still entails a sector with increasing work demands (9, 10). In countries with public eldercare, attempts have been made to strengthen *organizational capabilities* using different governance mechanisms to meet current and expected demands while upholding appropriate quality and efficiency (2). Also, new forms of ownership and organization have been trialed (11). However, multiple development projects being managed simultaneously without coordination may explain the poor results of such efforts in terms of capability and trustworthy developments (12).

Supportive and Hindering Conditions for Trustworthy Implementation

A systematic review of the barriers to and facilitators of welfare technology implementation in eldercare has identified the capacity of the old adults, employees, and eldercare organizations as a recurrent factor affecting implementation success (13). The work and leadership of first-line managers (FLMs) has been crucial for sustainable work by employees during the COVID-19 pandemic (3, 14). Earlier studies show that FLMs' efforts to link organizational levels to integrate perspectives and serve core purposes have achieved some success in terms of sustainable development in public care (15, 16). This puts high demands on managers and requires supportive organizational conditions and resources (17). However, poor vertical alignment, excessive managerial workload, and poor functional support have been identified as key obstacles to successful development work among FLMs (18). In fact, one central hindrance to the development and implementation of needed changes in healthcare is deficient practical operationalization of strategies (19–21) and a lack of vertical alignment within organizations (22). In eldercare, studies have reported challenges regarding vertical alignment due to insufficient resources and followup in the implementation process (20, 23, 24). To support organizational capability, development leaders (DLs) and change-supporting functions at different organizational levels can support the conversion of resources generated in development projects into improved practice at operational levels (25–27), i.e., trustworthy management. Methodological and contextual knowledge along with legitimacy in communicating and negotiating between organizational levels are key features of these roles (21, 28). There is little knowledge of the work and importance of DLs in managing necessary development work of different kinds during pandemic crises.

According to systems theory, the strengthening of resources necessary for capabilities needs to be informed by integrated perspectives that capture key conditions for development work and various resources at all system levels (29). This is supported by recent case studies in eldercare showing that resources for and perspectives on capability must be addressed at all organizational levels in order to support improvement and development work (13, 24, 30). A logic suggested to be more successful for public health and social service is to strengthen integrated values (31) in order to support the sustainable development of the capabilities of elders, employees, and eldercare organizations (32). The interaction between development strategies at the strategic and operational management levels can explain the success and sustainability of development work (33).

Aim

This study contribute knowledge about capability-strengthening development work in eldercare and its importance for trustworthy managerial work, before and during the COVID-19 pandemic. The following research questions were addressed: Who's capabilities are focused on and who is initiator, driver and active participant in the development project? What capability-strengthening projects are actively conducted in eldercare units? How are FLMs' trustworthy managerial work associated with the development projects, their workload and development support?

MATERIALS AND METHODS

Study Design

A mixed-method design, with parallel qualitative and quantitative data-collection and analysis, was chosen to explore, identify and assess ongoing development work in municipal eldercare organizations. The research questions were answered using data from semi-structured interviews with DLs, organizational documents, and questionnaire data with FLMs. Ethical approval was given by the Regional Ethics Committee (Dnr: 2019-02934).

Setting

Eldercare in Sweden is provided by a comprehensive public care system covering all citizens and funded by tax revenue. Various laws and regulations cover older people's choice of care and living arrangements, i.e., the Social Service Act (2001:453), Healthcare Act (2017:30), and Freedom of Choice Act (2008:962), and appropriate working conditions, i.e., the Work Environment Act (1977:1160) (34). These are followed up within eldercare organizations and by government authorities such as the Health and Social Care Inspectorate. The municipalities have the responsibility for providing good and safe eldercare for their citizens. Since the 1990s, the state has financially supported development work, through The National Board of Health and Welfare and by means of several national training initiatives. The purpose of these programs is to subsidize and incentivize, for example, development work focusing quality improvements and measures to increase the competence of the eldercare workforce. Depending on their size and economic conditions, municipalities have central development units supporting development work within eldercare. Where applicable, municipalities have assigned local DLs to work closely with operational eldercare management. FLMs are responsible for the service quality, personnel, working conditions, efficiency, and budget at their units; as such, they are responsible for integrating and putting into practice multiple values, perspectives, and policies of eldercare.

Study Sample

First, a questionnaire was distributed to eldercare FLMs in a random selection of 33 of Sweden's 290 municipalities. The selected municipalities were geographically situated in the northern, southern, eastern, and western parts of the country. These municipalities came from eight of the nine categories of municipalities, based on structural parameters such as population and commuting patterns (35). The randomly selected municipalities did not include any large cities, so one of Sweden's three large cities was also selected—for practical reasons, the nearest one. In the selected municipalities, all eldercare FLMs were identified through websites and direct contact with administrators. In the large city, a list of all FLMs, including their email addresses, was provided by the municipal administration.

The questionnaire was distributed via personal email addresses in the winter of 2019–2020 (T1), to 548 FLMs understood to be FLMs. 284 agreed to participate (response rate 52%). The followup (T2) questionnaire was sent in May–June 2021 to 472 eldercare managers understood to be FLMs. Of the 206 managers who completed the questionnaire, 189 were actually FLMs (response rate, 40%).

Second, during March–June 2021 14 municipalities varying in size, proportion of old adults living in assisted livings, and geographic location were selected for deeper investigation. In these municipalities, documentation of development work strategies was obtained and the support functions for development work were identified. These support functions were identified in all 14 municipalities, in some at multiple organizational levels. These development-supporting roles (henceforth, development leaders [DLs]) in the municipalities' elder care were: a) appointed DLs at different organizational levels, b) development managers responsible for development within a certain part of social care, or c) project managers, DLs, or care professionals assigned responsibility for certain development projects. There were DLs placed in and supporting strategic management (in eight municipalities), DLs placed in and supporting operational management (in five municipalities), and DLs placed at the strategic level but supporting operational management (in five municipalities). In one municipality, there was no specially appointed development support at any management level, and in another municipality, the responsibility for development was given to different operational managers, depending on the project type, but with no special development support.

The interviewed *strategic-level DLs* ($n = 15$) had positions closer to the political level. *Operational-level DLs* ($n = 9$) either had a position at the same hierarchical level as the second line manager or worked in close communication and collaboration with the operational level. Four out of the 24 interviewees were men. 40% had manager positions. 29% had worked up to one year, 42% 1–3 years, and 29% 4–8 years in their position. Their backgrounds varied from several years of working in different positions within the same or another municipality in different social care fields, to backgrounds in behavioral or political science and industrial managerial work.

Data Collection

Interviews With Development Leaders

Semi-structured interviews were conducted with DLs at the strategic and operational levels regarding strategies, the development of organizational preconditions, and the rated state of the development work (i.e., in terms of focus, initiative, drive, and collaboration). The interviewees were asked to rate the actual state of the work, not the vision for it. The data were analyzed according to the interviewees' closeness to the strategic or operational level. Most interviewees found this rating quite difficult, but the rating of the most common to the third most common alternatives was easier; ranks 1–3 are therefore considered most reliable.

Questionnaire

The web-based questionnaire included items capturing managerial conditions, supporting resources, and improvement

work. In this study, the following variables were selected to answer the research questions.

FLMs' Development Conditions

FLMs' *development-supporting resources* were assessed using the item: "I have trusting cooperation with resource functions (i.e., developers, improvement managers, or the equivalent) in work on organizational improvement." FLMs' *excessive workload* was assessed using an index of four items (Cronbach's alpha = 0.83): working overtime, being unable to rest from work, not having time for all the work to be done, and private/family life suffering due to managerial responsibility. The items could be responded to on a scale ranging from (1) "No, not at all" to (5) "Yes, to a high degree." Both these variables came from the Gothenburg Manager Stress Inventory (36).

Active Development Work at Eldercare Units

The question capturing current organizational development projects with a strategic focus for the purpose of strengthening resources needed for capability improvement was developed through interviews with 80 strategic-level managers (forthcoming). The question started: "At your unit in the past year, have you driven or actively participated in development work/projects regarding," followed by a list of projects that could be responded to on a scale ranging from (1) "No, not at all" to (5) "Yes, to a very high degree." The examples of development projects were grouped according to the main focus of the resources in the development project, i.e., whether they were directed toward strengthening *older people's*, *employees'*, or *organizational capabilities* (see **Table 3**).

Trustworthy, Integrated Managerial Work

An index of six items assessing systematic occupational health and safety management practice was used (37). The question started: "Are you satisfied with your opportunities to fulfill your managerial responsibilities, in a trustworthy and safe manner, in the following areas," followed by *daily work*, *influence of the old adults*, *care quality*, *safety*, *employee influence*, and *working conditions*. The items could be rated on a scale ranging from (1) "No, not at all" to (5) "Yes, to a very high degree." The respondent could also respond: "Don't know/not relevant." The internal consistency was high (Cronbach's alpha = 0.90).

Documents

In the 14 municipalities selected for deeper investigation, certain organizational documents were requested following the interviews, to complement and validate interview data. These were documents on development and improvement work concerning organizational vision, strategies, and arrangements to support preconditions for improvement work at the operational level.

Analysis

The interviews and organizational documents were analyzed qualitatively. All interviews were transcribed verbatim and analyzed using thematic analysis (38). The structured questions in the interviews were analyzed according to the percentages of interviewees rating certain alternatives as the most emphasized/common/important, and other alternatives as the second most emphasized/common/important, and so on. The document analysis was conducted from the same basis as the interview analysis for both data sources to verify each other.

Data from the questionnaires administered to first-line managers were analyzed using: (a) descriptive analysis (m, sd, %) regarding driving or actively participating in development work; (b) explanatory analysis using a series of forward stepwise regressions to select the most statistically important active development work/projects in each focus area (i.e., older people's/employees'/organizational capability) of trustworthy managerial work; and (c) theoretical stepwise regression models assessing the importance of additional focus areas in active development work and the importance of FLMs' development conditions.

RESULTS

An overview of the data-collection phases and study-populations included to form the base for the analysis of capability-strengthening development work in eldercare are described in **Figure 1** and **Table 1**. The result of the analysis are described sequentially. First, the development work of DLs at the strategic and operational levels regarding focus, initiators, drivers and active participants are described. Second, the various operational development work conducted at eldercare units, including supportive conditions and impact on trustworthy, integrated managerial work are presented, based on questionnaire data answered by FLMs.

Development Work Among Development Leaders at the Strategic and Operational Levels

Development work was described by DLs as project driven and mainly applying a top–down perspective. The DLs perceived development work as having a poor likelihood of success, telling of few activities and measures to follow up or evaluate development work. This was seen also in documents only mirroring strategies and vision of development work, and not presenting any development activities, results, follow-up on development projects or organization's best practice. The poor operational-level implementation was understood by DLs to be affected by employees and FLMs who lacked competence, did not understand the core principles of implementation work, and sometimes even lacked basic healthcare competence to implement, for example, new hygiene routines. There was also talk of a culture of concentrating only on the core tasks of eldercare and of exhaustion and a fear of change following years of organizational restructurings.

"I think a lot depend on top management or so, what it looks like, what they push for and see as essential. But of course, if it goes on for many years and you cut down on.… Opportunities for learning and developing…you get a culture among staff that you stick to doing what you must with the least effort…yeah" (strategic level developer in a smaller municipality).

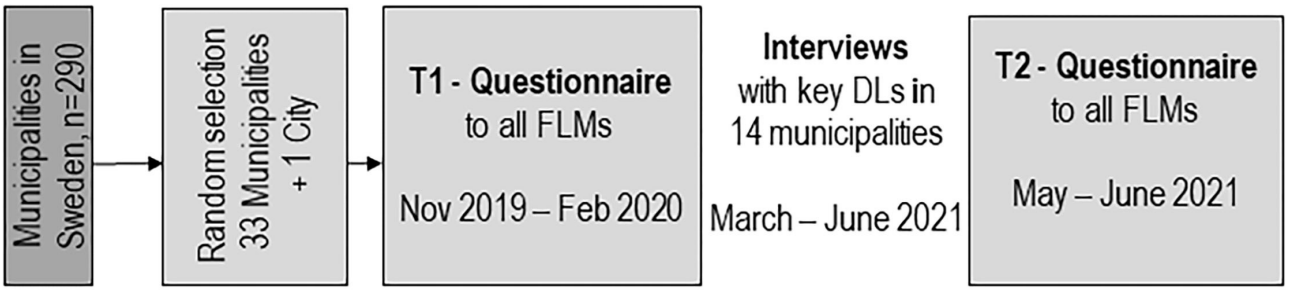

FIGURE 1 | Overview of the data-collection and study-populations.

TABLE 1 | Demographic information of responding first line managers (FLMs).

	T1	T2
FLM, responding/selected, *n* (%)	284/548 (52%)	189/472 (40%)
Municipalities, responding/selected *n* (%)	34/34 (100%)	27/34 (79%)
Female FLMs, *n* (%)	257 (90%)	166 (88%)
Age: 18–34 years, *n* (%)	18 (6%)	14 (7%)
35–54 years	168 (60%)	113 (60%)
55–67 years	98 (35%)	62 (33%)
Experience as manager, yrs (m/md)	13/12	12/11
Number of employees (m/md)	31/30	35/32

In several municipalities, project ownership was seldom implemented properly from the strategic to operational levels, as intended. One example was cited by a strategic-level interviewee who identified a bottleneck in the transition between the development unit and the homecare units. The operational level lacked sufficient resources to take over projects, which were consequently returned to the development unit, so the homecare units could not be accounted for in the implementation phase. Another example was a project in a mid-sized municipality in which grocery shopping by the old adults was digitalized in order to: (a) increase the influence of the old adults on the shopping; (b) minimize the manual handling of papers between the older people's homes and the homecare office; and (c) minimize the time spent on administration between visits by homecare staff. Instead of following the project plan for the implementation phase and following the instructions for using the iPads with the old adult, staff interpreted the instructions in their own ways. They continued to take food orders on paper, accumulating the shopping lists and submitting all the orders at once from the homecare office computer. This increased the administrative burden on staff between visits, so the goal of increasing the influence and involvement of the old adults was not attained. Another strategic level developer from a smaller municipality put it this way:

"And then you think that within home care or elder care, you get a bit scared too. Because when facing a new… "Oh my God, I don't know this computer system!" It's a challenge, to get people to learn new things. That we need to work differently. We have been working now… for like 30 years with these papers. But now we are facing digitalization. And then we need to catch up, you know."

Focus, Initiative, and Drive

Strategic-level DLs had a clear client perspective, and the development work was seen as a means of reaching the goals of the social or elder care political committee. Their work emphasized the influence and participation of the old adults. DLs working closely with the operational level focused more on development projects concerning employees' working conditions or old adults' security, and applied the perspective that employee well-being was a precondition for caring for the old adults. This was reflected in their rated *focus of development work* in eldercare. At the operational level, most rated "employee working conditions" as the first priority, vs. the strategic level, where most rated "old adults' influence on and participation in their own care" as the first priority (**Table 2**). About 60% of strategic-level respondents rated "employee working conditions" as the second priority. About 30% of operational-level respondents rated "old adults' security" as the first priority, while about 75% at the operational level rated "old adults' security" and "old adults' influence on and participation in their own care" as the second priority.

Regarding *stakeholders who demand or initiate development in eldercare*, all respondents rated "strategic management or politics" as the stakeholder most commonly initiating development efforts. Strategic-level respondents rated DLs as the stakeholder the second most likely to initiate development efforts, while operational-level respondents rated FLMs as the second most likely. In interviews, several DLs expressed a desire for more involved old people, their relatives, and operational-level management and employees when it came to generating ideas for development efforts, but they also said that the operational level lacked the conditions to prioritize such efforts.

Some strategic-level interviewees spoke of how they usually (before the pandemic) had dialogue meetings with citizens/the old adults and their relatives, and several wished that the old adults and their relatives would be more involved in generating ideas for development efforts. All DLs had optimistic, even

TABLE 2 | Focus, initiative, driver, and contribution for development projects in eldercare, rated by developments leaders.

Question	Rating alternatives	Strategic ($N = 15$) **n** Md (%)	Operational ($N = 9$) **n** Md (%)
Focus	Influence of old adults	**15** 1 (53%)	**9** 3 (44%)
	Working conditions	**15** 2 (60%)	**8** 1 (56%)
	Employee influence	**15** 3 (47%)	**8** 4 (67%)
	Safety issues	**15** 3 (33%)	**9** 2 (44%)
Initiator	Strategic mgmt./politics	**15** 1 (73%)	**9** 1 (56%)
	DLs/change agents	**14** 2 (60%)	**7** 3 (33%)
	FLMs	**14** 3 (33%)	**9** 2 (56%)
	Assistant nurses	**14** 4 (53%)	**8** 4–5 (22, 22%)*
	Old adults	**14** 5 (20%)	**9** 5 (22%)
	Relatives	**14** 5–6 (33, 20%)*	**9** 5 (22%)
	HR	**15** 7 (67%)	**8** 4–5 (22, 22%)*
Driver	Strategic level	**14** 1–2 (47, 20%)*	**8** 1–2 (44, 33%)*
	DL	**15** 2 (27%)	**8** 1–2 (44, 11%)*
	Operational level	**13** 3 (13%)	**8** 2–3 (44, 11%)*
	FLMs supported by DLs	**14** 3 (40%)	**8** 3 (44%)
	Employees supported by DLs	**14** 5 (53%)	**6** 5 (44%)
Active participant	FLMs	**15** 1 (73%)	**9** 1 (78%)
	Assistant nurses	**14** 2 (53%)	**9** 3 (67%)
	HR/other support function	**15** 3 (33%)	**8** 2 (56%)
	Old adults	**15** 4 (53%)	**8** 4 (67%)
	Relatives	**14** 5 (60%)	**8** 5 (67%)

Median rating (Md), number of interviewees (n), and percentage of total number of interviewees' (N) ratings according to median rating (%). Rating: 1 = most common, 2 = second most common, etc.
**Median rating of the alternative lying between two values, hence two percentages for the total number of interviewees.*
Bold only means to separate the numbers.

TABLE 3 | FLM-assessed conditions for development and ability to conduct trustworthy, integrated managerial work before COVID-19 (T1) and 16 months into the pandemic (T2).

	T1 m (sd)	T2 m (sd)
Development conditions		
Development support	3.41 (1.21)	3.61 (1.23) [a]
Excessive workload	3.14 (0.99)	3.30 (1.12)
Trustworthy, integrated managerial work	3.65 (0.41)	3.38 (0.81) [b]
– Safety of the old adults	2.19 (0.71)	3.33 (0.99)[a]
– Influence of the old adult	3.61 (0.93)	3.20 (1.05)[b]
– Working conditions	3.76 (0.87)	3.39 (0.95)[b]
– Employee influence	3.84 (0.90)	3.67 (0.94)
– Care quality	3.64 (0.89)	3.33 (1.06)[b]
– Daily work	3.67 (0.94)	3.28 (0.94)[b]

[a] *Increased T1–T2, Wilcoxon signed-rank test, $p < 0.05$.*
[b] *Decreased T1–T2, Wilcoxon signed-rank test, $p < 0.05$.*

naïve, beliefs about the importance of their contributions to the development work, rating "the strategic level" or DLs as the most common *drivers of development* in eldercare. All interviewees highlighted the importance of engaging the operational level in development, and many said that FLMs should be the key actors in driving change. Again, and as seen in the focus of the document narratives, the results indicate that this seemed to be more of a vision than the reality. Concerning *stakeholders actively participating in eldercare development*, interviewees at both levels agreed that FLMs were the most active contributors to development efforts; the next most active were "human resources or other supporting resource" or "assistant nurses."

First-Line Managers Development Work

Table 3 presents FLMs' assessments of their conditions for development work and their ability to conduct trustworthy, integrated managerial work. The development support increased during the pandemic. At T2, half of the FLMs (51%) received trustworthy organizational support from DLs. The managerial work on safety of the old adults was the lowest at T1 and had improved at T2. Almost all other aspects (except employee influence) of managerial work responsibilities, including summed trustworthy, integrated managerial work, had decreased.

Operational Development Work

A range of development projects was more or less actively driven at the operational level, with the intention of strengthening resources to bolster the capabilities of old adults, employees, and the eldercare organization. **Table 4** shows the degree of activity of development projects at T1 and T2. The most common

TABLE 4 | Active development work at eldercare units, for the purpose of strengthening resources for the capabilities of the old adults, employees, and eldercare organizations, and correlation with FLMs' trustworthy, integrated managerial work; p > 0.1 considered non-significant (ns).

	Descriptives m (SD)		Stepwise regressions Trustworthy, integrated managerial work r^2/r^2 adj.**, Beta (*p*-value)	
Development focusing on:	**T1**	**T2**	**T1**	**T2**
The old adults (Cronbach's alpha 0.75 resp. 0.61)	**2.37 (0.88)**	**2.65 (0.89)**	**0.19/0.18**	**0.22/0.20**
Digitization to strengthen eldercare quality	3.30 (1.36)	3.12 (1.29)	ns	ns
Increase influence of the old adults on operational decision-making	2.80 (1.24)	2.41 (1.12)	0.22 (0.00)	0.17 (0.03)
Develop models of businesses driven by employees and/or old adults (e.g., intrapreneurship and social entrepreneurship)	1.78 (1.28)	2.34 (1.13)	ns	0.22 (0.00)
Employees (Cronbach's alpha 0,74 resp. 0,75)	**3.06 (0.90)**	**2.84 (0.82)**	**0.25/0.24**	**0.30/0.29**
Digitization to decrease employee workload	3.19 (1.42)	2.95 (1.19)	ns	ns
Increase employee influence on operational decision-making	3.29 (1.17)	3.02 (1.24)	0.18 (0.00)	0.23 (0.00)
Technical development to decrease workload	2.67 (1.39)	2.5 (1.27)	ns	ns
Strengthen knowledge and competence to handle work	3.25 (1.13)	3.12 (1.08)	0.19 (0.00)	ns
Supervision or mentorship of newly recruited	2.99 (1.23)	2.70 (1.2)	ns	0.22 (0.00)
Organization (Cronbach's alpha 0.78 resp. 0.75)	**2.62 (0.84)**	**2.58 (1.04)**	**0.14/0.13**	**0.15/0.14**
Digitization to improve followup of care quality	2.63 (0.96)	2.61 (1.23)	ns	0.27 (0.00)
Digitization to improve followup of economic aspects	2.76 (0.98)*	2.33 (1.19)	−0.22 (0.00)	ns
Digitization to improve staff planning	2.47 (1.08)*	2.77 (1.35)	ns	ns

ns = p > 0,05.
**Not in the city. **r^2/r^2 adj. from stepwise regression for each resource dimension; variables were excluded if p > 0.1.*
Bold only means to separate the numbers.

development projects with a *focus on the old adults* concerned "digitization to improve eldercare quality" (active projects at 48% of the units at T1) and "increased influence of the old adults on operational decision-making" (active projects at 32% of the units at T1). The most common projects with an *employee focus* concerned "increased employee influence on operational decision-making" (active projects at 52% of the units at T1) and "strengthening competence" (active projects at 49% of the units at T1). Projects with an *organization focus* concerned "digitization to improve followup of a) care quality, b) economic aspects, and c) staff planning." These were common and active projects, with 65% of units actively involved in digitization related to economic aspects, 56% involved in digitization related to care quality, and 47% involved in digitization related to staff planning.

A series of forward stepwise regressions, one for each development focus, identified the development work with the greatest impact on trustworthy, integrated managerial work (**Table 4**). The highest explained variance of managerial work ($r^2 = 0.30$) was found at T2 in employee-focused development efforts, specifically projects addressing increased employee influence on operational decision-making and the introduction/mentorship of new employees. The projects focusing on the old adults explained about 20% of the variance in managerial work, specifically as regards increased influence of the old adults on operational decision-making at T1 and developing models of business driven by the employees and/or old adults (e.g., intrapreneurship and social entrepreneurship) at T2. Digitization of the followup of care quality explained 10–15% of the variance in trustworthy managerial work.

Importance of Development Work for Trustworthy, Integrated Managerial Work

In stepwise models 1–4, the contribution of operational development work to strengthening FLMs' managerial work at T2 was modeled (**Table 5**). Model 1 showed the importance of FLMs' organizational support from DLs, and the importance of this support was further examined in the following models. Models 2–4 included the operational development work focusing on the capabilities of eldercare organizations, the old adults, and finally employees. FLMs' development support explained 6% of the variation. The development work explained 23% of the variation, most strongly for the employee-focused development work. The final model also included the main obstacle—FLMs' excessive workload. This had some impact and explained an additional 15% of the variance in trustworthy managerial work. The same modeling was conducted for T1 with about the same pattern of associations: the employee-focused development work and FLMs' excessive workload had the strongest associations with trustworthy managerial work, while FLMs' development support, a focus on the old adults, and an organizational focus had weaker associations. The final model explained 36% of the variance at T1 and 44% at T2.

DISCUSSION

The aim of this study was to build knowledge of development work to strengthen resources supporting the capabilities of the old adults, employees, and eldercare organizations. This aim was operationalized by addressing three research questions

TABLE 5 | Stepwise models of the importance of FLMs' development conditions and implemented resources for trustworthy, integrated managerial work at T2.

	Trustworthy, integrated managerial work Beta (*p*-value)				
	Model 1	**Model 2**	**Model 3**	**Model 4**	**Model 5**
Development support	0.17 (0.03)	0.27 (0.00)	0.12 (0.10)	0.12 (0.09)	0.09 (0.14)
Development work					
Organizational focus		0.13 (0.08)	0.18 (0.04)	0.17 (0.04)	0.09 (0.14)
Focus on the old adults			0.25 (0.02)	0.08 (0.55)	0.06 (0.60)
Employee focus				0.23 (0.04)	0.26 (0.01)
Excessive workload					−0.28 (0.00)
Intercept	2.73	2.17	1.86	1.63	2.59
R^2	0.07	0.22	0.29	0.34	0.48
R^2 adj.	0.06	0.20	0.25	0.29	0.44

concerning: the development work targeted by DLs at the strategic and operational levels in eldercare; the operational development work at eldercare units and its importance for FLMs' trustworthy, integrated managerial work; and the FLMs' development conditions in terms of workload, development support, and the association with their trustworthy, integrated managerial work.

Answering the first questions, the study identified multiple ongoing development projects in eldercare with the objective of strengthening resources for eldercare organizations, the old adults, and employees. However, active driving of and participation in these projects at operational levels were limited. Strategic-level DLs reported the greatest emphasis on the influence of the old adults on eldercare development, while operational-level DLs reported the greatest emphasis on employee working conditions, in line with most work-unit activity being projects with an employee focus. There is reason to believe that, from an FLM perspective, employee working conditions are seen as a precondition for offering trustworthy eldercare, both before [see, e.g., (15, 17)] and here during the pandemic.

Unsurprisingly, FLMs' managerial work on the safety of the old adults increased during the pandemic, apparently at the expense of almost all other aspects of trustworthy, integrated managerial work (i.e. quality of care, influence of the old adults, daily work and working conditions). Further, also all kinds of development work decreased during the pandemic except digitization to improve staff planning which was increased. FLMs' development support also increased somewhat during the pandemic, but remained moderate. This was confirmed by operational-level DLs, who stated that development work co-driven by DLs and FLMs was not as common as at the strategic level or as purely DL-driven development work. Still, DLs highlighted FLMs as the most active drivers of eldercare development work. The development support had some positive impact, while excessive workload obviously had some negative impact. Summed up, the development conditions had some importance, but operational-level employee-focused development work was the most important for FLMs' perception of performing trustworthy, integrated managerial work. Despite operational development work being somewhat limited 16 months into the pandemic, ongoing development work seemed especially important for FLMs' perceptions of their own managerial work during the pandemic.

The findings suggest that there is synergy between strategic-level development work, operational-level development work, and FLMs' personal ratings of their resources for performing managerial work in a trustworthy, integrated way. These kinds of synergies were earlier discussed in relation to the capability set concept (5) and the crafting of sustainable work through the development of personal resources, translated to employees' work ability and collaborative work crafting (39). Thus, active participation in development work in one's own unit seems to create learning, strengthening the FLM's ability to contribute to overall organizational capability. The capability set may also entail difficulties for managers struggling to convert resources due to their excessive workload. Support for this interpretation can be found in studies showing associations between managers' work performance and their stressors and excessive workload (18, 40). Other studies of healthcare have identified stressors in terms of hard control and top-management demands impinging on the work of FLMs (28, 41). This study builds knowledge of the importance of excessive workload for the capacity to perform trustworthy, integrated managerial work that integrates important capabilities of eldercare service of value for the old adults, employees, and the eldercare organization.

When elaborating on the answer to the last research question, the findings also raise questions regarding the development support in terms of content of the resource. Multiple, parallel projects (12) and limited development support likely constrain FLM potential to be a resource in strengthening organizational capability. Over the last four decades, various models, or best practices, have emerged to fit and strengthen resources in different contexts (42). DLs are commonly part of the facilitating processes when implementing change. As mentioned above, the present results as well as results of previous healthcare change management research (27) tell of high expectations of FLMs as change drivers in organizational development. However, the FLM role is restricted to a certain unit in an organizational hierarchy. Development support from DLs or change agents

has been stressed as important in order to ease the burden on FLMs as well as to take responsibility for aligning strategy and operationalization when driving change (27, 28). Is the insufficient development support for FLMs studied here based on a lack of development-supporting resources in the municipalities, or is it because the supporting resources do not meet the needs of the FLMs or help them in aligning operations with strategy?

Today's poor conditions for capability among old adults and the external pressure to develop eldercare due to ongoing demographic shifts points toward new ways of organizing as well as toward digitization and the implementation of welfare technology. Critical factors seen to affect the implementation of new technology are, besides capacity and aHealth literacy, as mentioned in section 1.2, attitudes and values in the eldercare workforce (13). The present study also identifies the diverse importance related to aim and focus of digitalized developments, i.e. digitization to increase influence vs. followup of economic aspects. The further development of eldercare also depends on the sustainable work of FLMs who have the supporting resources in place to ease their workload and increase time spent on driving change.

This research has certain limitations and strengths that merit consideration. Strengths that made the interpretation of findings more valid were: (a) the comparatively wide-ranging sampling across Sweden, including a random selection of municipal eldercare organizations; (b) the combination of qualitative and quantitative data; and (c) the stepwise systematic data collection using validated measures. Limitations of the sample were (a) the poor response rate (56 and 40% at T1 and T2, respectively), and (b) the high FLM turnover, limiting the ability to follow up individual FLM responses.

CONCLUSIONS

Development work regarding the safety of the old adults and digitization of staff planning increased during the pandemic, while other kinds and aspects of development work decreased or remained at the same level. Further, the study confirms the previously noted abundance of development work being conducted in eldercare in Sweden. The focus of this development work differed depending on where in the eldercare organization one asked questions about it. Eldercare DLs at the strategic level told of prioritizing the influence of the old adults, while DLs working closer to the operational level told of prioritizing employee influence and working conditions. Most development work was initiated and driven by the strategic level, despite the strong conviction that FLMs ought to be the best change drivers in implementation. However, excessive workload and moderate development support hindered FLMs trustworthy managerial work. They worked most active with approaching capability-strengthening projects focusing employees' resources. This focus was also most strongly associated with their rated performance of trustworthy, integrated managerial work. While the capability set for other projects seem not to be at place. These findings call for the further investigation of a suitable development support functions, both to ease FLMs excessive workload and to increase their opportunity for active approaching capability-strengthening developments in eldercare.

DATA AVAILABILITY STATEMENT

The 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 Regional Ethics Committee (Dnr: 2019-02934). The patients/participants provided their written informed consent to participate in this study.

AUTHOR CONTRIBUTIONS

LD and AW have both participated in the conception of the study, study design, and interpretation of the overall analysis. LD has managed the distribution of the survey, the quantitative analysis of the survey results, and drafted the manuscript. AW has performed the interviews, analysis of interviews and documents, complemented with texts, and critically revised the manuscript. Both authors contributed to the article and approved the submitted version.

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Queueing Theory and COVID-19 Prevention: Model Proposal to Maximize Safety and Performance of Vaccination Sites

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Introduction: COVID-19 (Coronavirus Disease 19) has rapidly spread all around the world. Vaccination represents one of the most promising counter-pandemic measures. There is still little specific evidence in literature on how to safely and effectively program access and flow through specific healthcare settings to avoid overcrowding in order to prevent SARS-CoV-2 transmission. Literature regarding appointment scheduling in healthcare is vast. Unpunctuality however, especially when targeting healthcare workers during working hours, is always possible. Therefore, when determining how many subjects to book, using a linear method assuming perfect adhesion to scheduled time could lead to organizational problems.

Methods: This study proposes a "Queuing theory" based approach. A COVID-19 vaccination site targeting healthcare workers based in a teaching hospital in Rome was studied to determine real-life arrival rate variability. Three simulations using Queueing theory were performed.

Results: Queueing theory application reduced subjects queueing over maximum safety requirements by 112 in a real-life based vaccination setting, by 483 in a double-sized setting and by 750 in a mass vaccination model compared with a linear approach. In the 3 settings, respectively, the percentage of station's time utilization was 98.6, 99.4 and 99.8%, while the average waiting time was 27.2, 33.84, and 33.84 min.

Conclusions: Queueing theory has already been applied in healthcare. This study, in line with recent literature developments, proposes the adoption of a Queueing theory base approach to vaccination sites modeling, during the COVID-19 pandemic, as this tool enables to quantify ahead of time the outcome of organizational choices on both safety and performance of vaccination sites.

Keywords: COVID-19, vaccination site, queueing theory, physical distancing, safety and performance

INTRODUCTION

Since the report of a first suspected case on December 8, 2019 in Wuhan, Coronavirus disease 2019 (COVID-19) has rapidly spread all around the world (1). Induction of herd immunity by mass vaccination has been a very successful strategy for preventing the spread of many infectious diseases, hence protecting the most vulnerable population groups unable to develop immunity, for example individuals with immunodeficiencies or a weakened immune system due to underlying medical or debilitating conditions. Therefore, vaccination represents one of the most promising counter-pandemic measures to COVID-19 (2). Finding safe and effective vaccination models has, therefore, become a global priority.

However, there is still little specific evidence in literature on how to safely and effectively program access and flow through specific healthcare settings to avoid overcrowding in order to prevent SARS-CoV-2 transmission (2).

A systematic review commissioned by the World Health Organization attempted to analyse physical distancing measures in relation to coronavirus transmission (3). Physical distancing of <1 m (meter) was reported to result in a transmission risk of 12.8%, compared with 2.6% at distances ≥ 1 m, supporting physical distancing rules of 1 m or more (4). It is vital, therefore, to program access to facilities and services so that adequate physical distancing is guaranteed, and overcrowding is avoided, especially in the context of massive vaccination campaigns.

The problem of overcrowding in healthcare setting has mostly been faced in literature in the past with regards to Emergency Departments (5, 6). Literature regarding appointment scheduling in healthcare is vast (7–13). However, due to the inherent characteristics of medical services, it is difficult to predict exactly when a patient will arrive and how much time will be taken for the service (14). Even in the case of highly standardized practices such as vaccination, variability due to unpunctuality is always possible (15). This is especially true when targeting people during working hours, with some of them conducting busy and often unpredictable daily activities.

One of the approaches that could help solve this problem is "Queueing theory" (5, 6, 16). Queueing theory is a branch of applied mathematics that is used to predict the behavior of lines (also known as queues). A process is made up of a sequence of activities with various points of delay and stoppages. Flow units enter the process (arrivals), wait to be processed (queue), are processed (service), and then move to the next step in the process or exit it. The time spent in line or queue is a function of the configuration and discipline rate at which the flow units enter the system, the rate at which they are processed or served, the queue, and the population of flow units (5). To give some definitions: Server, s: the main unit providing service; Average Arrival Rate, λ: the average number of arrivals per unit of time; Average Service Rate, μ: the average number of units served or processed per unit of time. The Kendall notation is a well-established classification scheme. Three letters are used, M, G, and D, to designate the probability distributions of arrivals or service: M = Poisson distribution for rates or exponential distribution for times (the "M" stands for Markovian and/or "memoryless"); G = General/any distribution with a known mean and variance; D = Deterministic or constant.

"Queueing theory" has been mostly applied in healthcare (16) to enhance the performance of operating rooms (17), outpatients settings waiting times (8) and hospital bed management (18). It is starting to be applied to vaccination campaigns as well (2). A recent study of Safdar et al. (19) presents a novel application of DEA (Data Envelopment Analysis) for assessing the queuing process at an outpatients' department of a large public hospital in a developing country where appointment systems do not exist. DEA has been mostly applied to the efficiency comparison of hospitals (20–25). In this study the patient flow pathway considered consisted of two stages: consultation with a doctor and pharmacy. The DEA results indicated that waiting times and other related queuing variables included need considerable minimization at both stages. This is an important result of a study from a context in which appointment systems do not exist.

Our paper proposes the use of Queuing theory to provide a model for quantifying in advance how many healthcare workers to be booked daily for a vaccination site, taking into account the possible variations due to healthcare workers not being able to perfectly adhere to their scheduled arrival time, and to provide indicators of safety, with regards to physical distancing during the COVID-19 pandemic, and performance, with regards to utilization time of each unit and to the subjects' average waiting time.

METHODS

The main way to approach the subject of booking units to input in a healthcare service consists in appointment scheduling techniques. This is proved to be very efficient, however there is scarce literature and techniques to use in many real contexts such as ours in which reliance on subjects respecting their scheduled times would be unwise. In relation to this topic, scientific literature provides many tools such as Monte Carlo simulation (26), Discrete Event Simulation (DES) (27), agent-based simulation (28) and Data Envelopment Analysis (DEA) (19). We found queueing theory to be easy to be understood and applied by professionals from all healthcare sectors as it does not require high-demanding computing or technical skills, it is well supported by literature (8, 16–18) and it has already been successfully applied to vaccination settings (2).

A vaccination site for COVID-19 vaccination targeting healthcare workers based in a teaching hospital in Rome was studied. The Queuing theory model used is G/D/s/k/∞/FIFO. The characteristics of each parameter and the reason for making such choices regarding the type of queue model used are the following:

- G stands for a distribution with a known mean and variance. In order to derive a realistic coefficient of variation (CV) of arrival rate we therefore studied the recorded distribution of arriving subjects throughout the 3 days of major affluence, from 8th to 10th January 2021. These days were also the most homogenous with regards to number of subjects served and hours of activity (**Table 1**) and represented a situation of maximum stress for the

system. Five-minute time slots for each of the three stations were available for booking. No more than 1 booking for time slot was possible;

- D this stands for service time. It was assumed to be constant (meaning a coefficient of variation equal to zero) and equal to 5 min, based on the average time needed for vaccination gained in our experience. This parameter was therefore used to determine the entity of each time slot;
- s stands for the number of stations, i.e., the total number of working stations. All vaccination sites were considered to have three stations, each one composed by: one public health medical doctor explaining the procedure, interviewing the healthcare worker and excluding any contraindication to the procedure (i.e., allergic to substances contained in the vaccine) and one nurse taking care of preparing and administering the vaccine shot;
- k stands for a maximum fixed length of the queue (or Lq). The maximum allowed length of the queue in all vaccination sites (determined in relation to the real-life setting waiting room space) was considered to be 20;
- ∞ stands for the entity of the population set. It was assumed to be infinite so as to give maximum possible variability to arrival rate throughout the simulations in order to find the most appropriate value for it;
- FIFO stands for the Queue discipline. The "first in–first out" order ("FIFO", otherwise known as "FCFS" or first come–first served) was chosen, meaning that no subject could access the server before the end of the previous vaccination process; no system of priority other than arrival time was in fact considered;

The time unit was assumed to be 6 h for the first simulation, as this was the amount of time dedicated to vaccination in our original hospital-based setting. It was assumed to be 12 h for the second and third simulation, in order to have a double amount of time for vaccination but without making the staff exceed 12 consecutive working hours.

Therefore, Queueing theory indicators to study the model were used.

For the safety analysis, to make sure adequate physical distancing was kept, we used average Length of queue (Lq);

For the performance analysis we used: ρ = percentage of the total time each station was in use, with 100 – ρ being a measure of resources underutilization; AWT = average subject's waiting time;

We therefore performed three simulations to study the activity using the aforementioned indicators in:

- a hypothetical setting modeled on the original;
- a hypothetical double-sized original setting;
- a hypothetical mass vaccination site.

The result of the simulations in each setting was confronted with a linear model booking system as the starting point and the value of the arrival rate was lowered unit by unit for each simulation.

For all graphs and analysis Microsoft Excel for Mac (Version 16.16.27-201012) was used. Example of formulas for Excel-based queueing model building are open access and freely available (for instance at https://www.csus.edu/indiv/b/blakeh/mgmt/documents/opm101supplc.pdf). As a G/D/k model tailored to the specific requirements of our study requires complex computational capacity, safety and performance indicators were obtained using an online calculator (29). The parameters of interest used in each simulation were defined in the Results section. Other parameters available were not modified from the default calculator mode and assigned as such: arrival batch size = 1; batch size (service process) = 1; coefficient of variation of service process (given service rate was a fixed parameter) = 0. The last 3 parameters, regarding failure behavior of the model, were assigned as: availability = 1; average down time = 0; coefficient of variation = 1.

The obtained values for queue length with decimal digits were rounded to the integer value. The obtained value for AWT was converted by multiplying it by the established time unit in minutes for each simulation.

Figures 1–3 illustrate the following findings.

Figure 4 shows a flow chart demonstrating how each step has been undertaken.

RESULTS

Determining Arrival Distribution

Table 1 shows data regarding the activity during the three sampled vaccination days.

A mean CV of 0.69 across the 3 days was observed and therefore used for the simulations to determine arrival distribution. In fact, the percentage of time slots with more than 3 arriving subjects, which should amount to zero in an ideal setting with perfect adherence of subjects to the scheduling, were found to be, respectively, 10.90, 18.99 and 17.24% across the 3 days.

Original Setting

For the first simulation we considered a service rate (the rate of served subjects per total working session) of 72 subjects served by each station, 3 stations (each station composed by a doctor-nurse unit) working in parallel, 5 min were designated as the time slot needed for each vaccination, the maximum number of subjects that could stay in the queue in compliance with the COVID-19 safety requirements in relation to the real-life space at disposal was 20, the total working time of the site was 6 h and 0.69 was the coefficient of variation of the arrival rate as determined in paragraph 3.1. A linear booking model was used as a starting point, multiplying the service rate by the number of working stations and obtaining 216 as the number of subjects (λ, arrival rate) to be booked for the day.

We therefore proceeded with a more complex approach based on Queueing theory, varying the arrival rate simulation by simulation starting with 216 and performing a safety and performance analysis on each simulation's outcome via the indicators mentioned in the Method section.

The safety analysis showed that, an arrival rate λ of 214, we would have 25 subjects in the queue (Lq), exceeding the safe queue limit by 5. We therefore performed another simulation and

TABLE 1 | Details of the activity regarding the three sampled vaccination days.

Vaccination day	No. of subjects	Working hours (time slots)	Mean vaccinated per time slot (std. dev.)	Coefficient of variation (CV)
8th January	174	6.66 (80)	2.18 (1.47)	0.67
9th January	179	6.25 (75)	2.39 (1.72)	0.72
10th January	174	6.00 (72)	2.41 (1.66)	0.69

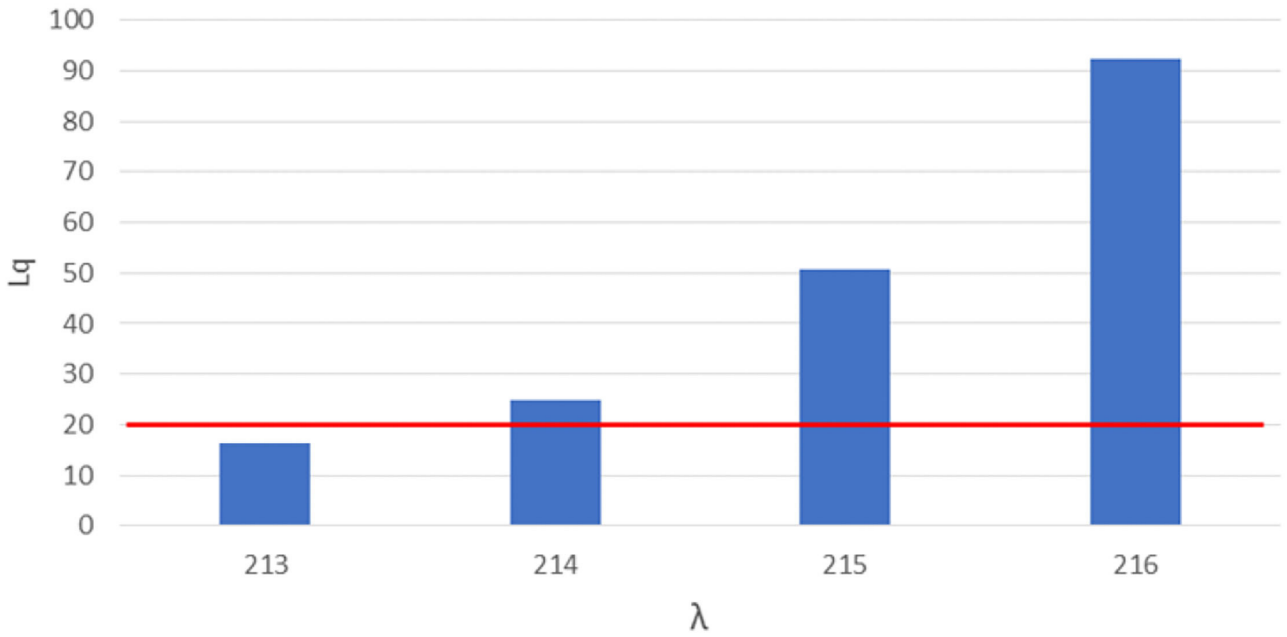

FIGURE 1 | Number of queueing subjects (Lq) by one-unit increases in arrival rates (λ) in original setting. Maximum queue length evidenced in red line.

found 213 as the threshold arrival rate value for safety by which the queue amounts to 20 subjects.

The performance analysis showed that, with 213 as arrival rate we found 98.6% as the percentage of time each station was in use (ρ), which implies underuse of 1.4% of each station's time. 27.72 min were determined as the average time each subjects had to wait in line (AWT or average waiting time).

A difference of 3 subjects in determining the appropriate arrival rate was therefore found between a linear approach by simple multiplication (assuming a coefficient of variation of arrival rate equal to zero) and a more complex Queueing theory approach (assuming a coefficient of variation of arrival rate derived from a real-life setting observation).

However little could seem this difference, as shown in **Figure 1**, letting in a few more units could cause an exponential growth of Lq, with a difference of 3 more booked subjects (from 213 to 216) causing an increase of 112 subjects over the safe limit of the waiting queue (from 17 queueing subjects with an arrival rate of 213 to 128 queueing subjects with an arrival rate of 216).

Figure 1 shows the number of queueing subjects by one-unit increases in arrival rates in original setting, maximum queue length is evidenced in red line.

Double-Sized Setting

For the second setting we considered a service rate (the rate of served subjects per total working session) of 144 subjects served by each station, 6 stations (each station composed by a doctor-nurse unit) working in parallel, 5 min were designated as the time slot needed for each vaccination, the maximum number of subjects that could stay in the queue in compliance with the COVID-19 safety requirements in relation to the real-life space at disposal was 40, the total working time of the site was 12 h and 0.69 was the coefficient of variation of the arrival rate as determined in paragraph 3.1. A linear booking model was used as a starting point, multiplying the service rate by the number of working stations and obtaining 864 as the number of subjects (λ, arrival rate) to be booked for the day.

We therefore proceeded with the approach based on Queueing theory, varying the arrival rate simulation by simulation starting with 864 and, as for the first setting, performing a safety and performance analysis on each simulation's outcome.

The safety analysis showed that, already at an arrival rate λ of 860, 51 subjects are found in the queue (Lq), exceeding the safe queue limit of 40 by 11 units. We therefore performed another simulation and found 859 as the safe arrival rate value by which the queue amounts to 40 subjects.

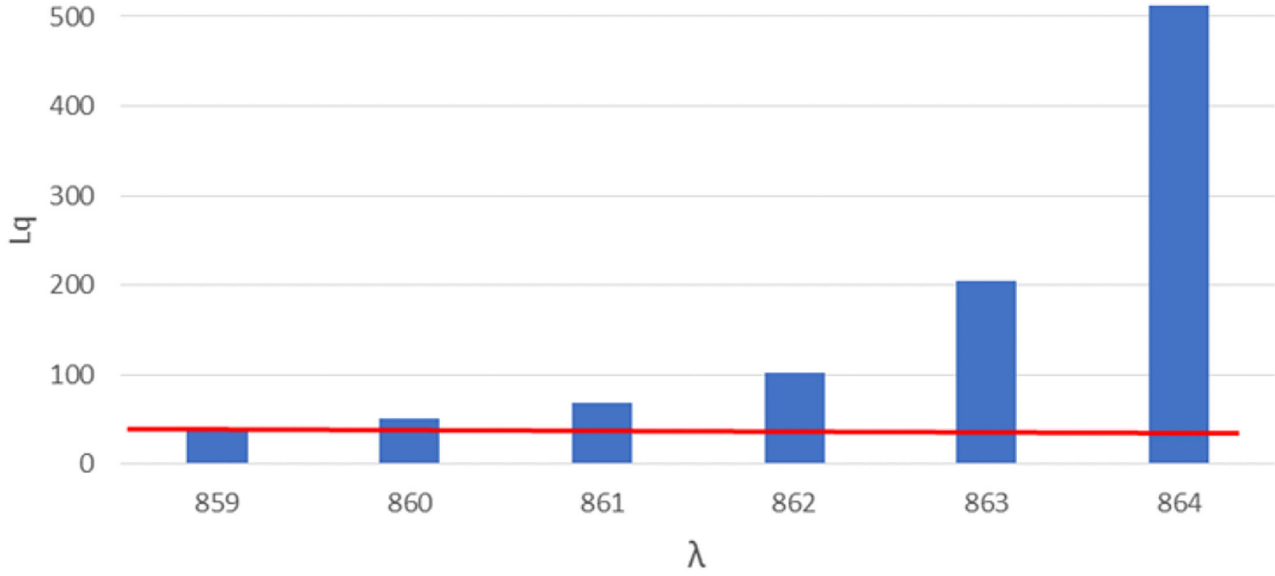

FIGURE 2 | Number of queueing subjects (Lq) by one-unit increases in arrival rates (λ) in double-sized setting. Maximum queue length evidenced in red line.

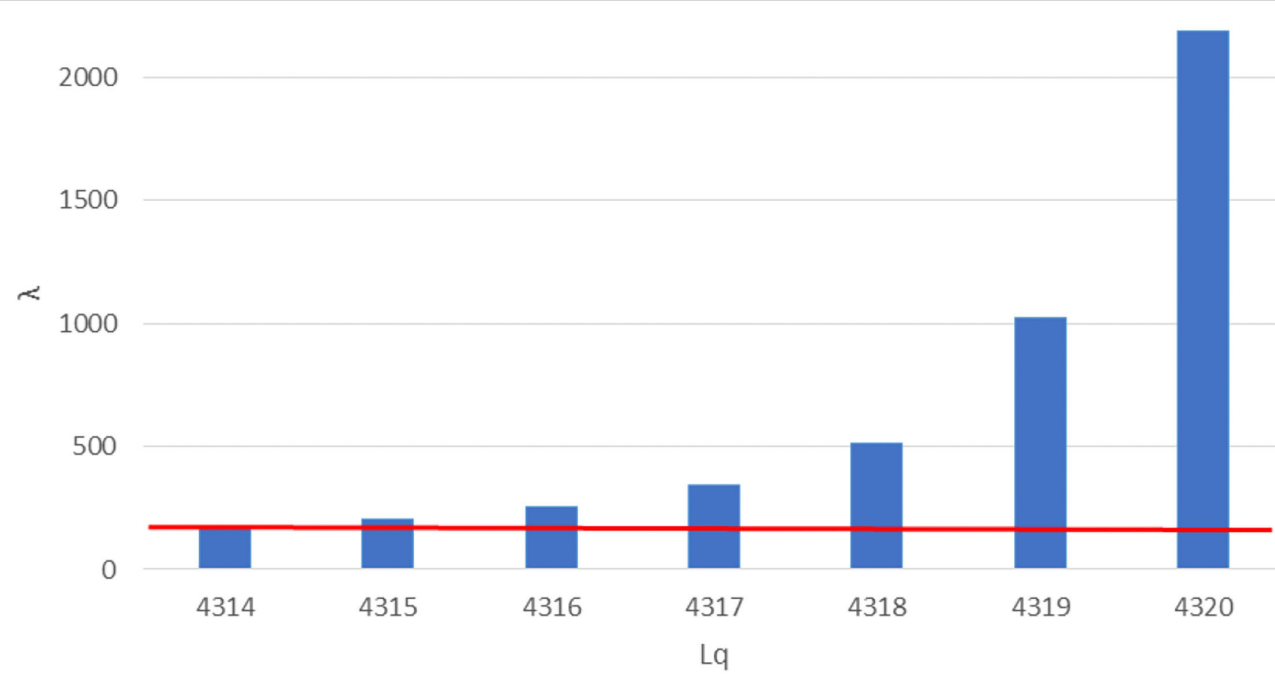

FIGURE 3 | Number of queueing subjects (Lq) by one-unit increases in arrival rates (λ) in mass vaccination site. Maximum queue length evidenced in red line.

The performance analysis showed that, with 859 as arrival rate, we found 99.4% as the percentage of time each station was in use (ρ), which implies underuse of 0.6% of each station's time, and an average waiting time of 33.84 min.

A difference of 5 subjects in determining the appropriate arrival rate was therefore found between a linear approach by simple multiplication (assuming a coefficient of variation of arrival rate equal to zero) and a more complex Queueing theory approach (assuming a coefficient of variation of arrival rate derived from the observation a real-life setting).

However little could seem this difference, as shown in **Figure 1**, letting in a few more units could cause an exponential

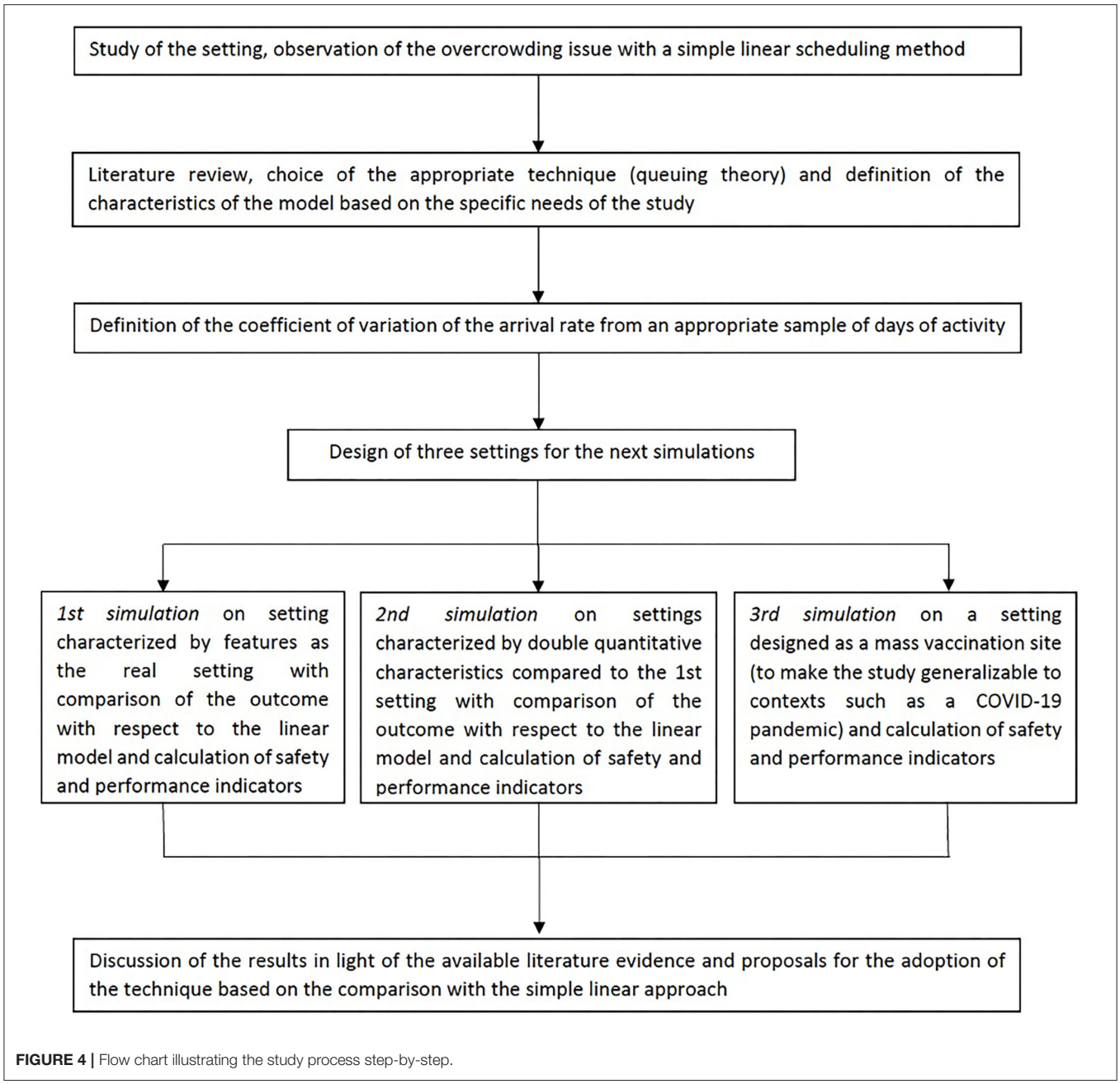

FIGURE 4 | Flow chart illustrating the study process step-by-step.

growth of Lq, with a difference of 5 more booked subjects (from 859 to 864) causing an increase of subjects over the safe limit of the waiting queue of 483 subjects (from 40 queueing subjects with an arrival rate of 859 to 523 queueing subjects with an arrival rate of 864).

Figure 2 shows the number of queueing subjects by one-unit increases in arrival rates in original setting, maximum queue length is evidenced in red line.

Mass Vaccination Site

For the third setting we considered a service rate (the rate of served subjects per total working session) of 144 subjects served by each station, 30 stations (each station composed by a doctor-nurse unit) working in parallel, 5 min were designated as the time slot needed for each vaccination, the maximum number of subjects that could stay in the queue in compliance with the COVID-19 safety requirements in relation to the real-life space at disposal was 40, the total working time of the site was 12 h and 0.69 was the coefficient of variation of the arrival rate as determined in paragraph 3.1. A linear booking model was used as a starting point, multiplying the service rate by the number of working stations and obtaining 4,320 as the number of subjects (λ, arrival rate) to be booked for the day.

We therefore proceeded with the approach based on Queueing theory, varying the arrival rate simulation by simulation starting with 4,320 and, as for the first setting, performing a safety and performance analysis on each simulation's outcome.

The safety analysis showed that, already at an arrival rate λ of 4,315, 204 subjects are found in the queue (Lq), exceeding the safe queue limit of 40 by 4 units. We therefore performed another simulation and found 4,314 as the safe arrival rate value by which the queue amounts to 170 subjects.

The performance analysis showed that, with 4,314 as arrival rate, we found 99.8% as the percentage of time each station was in use (ρ), which implies underuse of 0.2% of each station's time, and an average waiting time of 33.84 min.

A difference of 6 subjects in determining the appropriate arrival rate was therefore found between a linear approach by simple multiplication (assuming a coefficient of variation of arrival rate equal to zero) and a more complex Queueing theory approach (assuming a coefficient of variation of arrival rate derived from the observation a real-life setting).

However little could seem this difference, as shown in **Figure 1**, letting in a few more units could cause an exponential growth of Lq, with a difference of 6 more booked subjects (from 4,314 to 4320) causing an increase of 750 subjects over the safe limit of the waiting queue (from 170 queueing subjects with an arrival rate of 4,314 to 855 queueing subjects with an arrival rate of 4,320).

Figure 3 shows the number of queueing subjects by one-unit increases in arrival rates in original setting, maximum queue length is evidenced in red line.

DISCUSSION

As anticipated in the Results section, the percentage of time slots with more than 3 arriving subjects, which should amount to 0.00% in an ideal setting with perfect adherence of subjects to the scheduling, were found to be, respectively, 10.90, 18.99 and 17.24% across the 3 days. This proves that unquestioned reliance on subjects respecting their scheduled times would be unwise.

With regards to safety analysis, comparing the results obtained by three simulations we can see that the number of subjects prevented from overcrowding the vaccination site increases exponentially with the increase in size and in the chosen parameters of the site.

With regards to performance analysis, we can see the highest performance in terms of percentage of stations' time in use and average waiting time is found in the mass vaccination site, followed by the double-sized setting and the original setting simulation.

We see how Queueing theory, allowing for performance and safety analysis, shows its greatest potential with mass vaccination sites, though proving useful in smaller setting as well.

We observed that the most effective model had, respectively, 5 and 10 times the number of servers, 5 and 10 times the number of places for queueing and twice and the same number of working hours of the second and first simulated models.

The opportunity of applying Queueing theory is supported by recent literature.

A study by Hanly et al. (2) makes an important use of this theory in modeling the entirety of vaccination sites. The experimenters conclude by reporting that "[..] queueing models can be used to simulate vaccination queues, estimate daily throughput based on given staff availability and inform service delivery".

To conclude, our choice of the parameters in building different models for simulation was demonstrational. Future use of the model could therefore consist in studying, for instance, how many more subjects can be vaccinated, while ensuring maximum performance and safety of the site, by differentially increasing one parameter at a time to find the most suitable configuration in relation to the specific organizational requirements of the user.

Study Limitations

This study has some limitations.

First, even though a distribution of variability of service rate could have proven useful in improve adherence to real-life setting (some subjects take more or <5 min to be vaccinated according, for instance, to the complexity of the health status assessment), such data were unfortunately not recorded. Service rate CV was therefore assumed equal to zero for the sake of our simulations. A "D" (deterministic) instead of a "G" distribution was adopted. Based on our experience, however, we reckon that much of the variability in the process is attributable to arrival rate rather than service rate. We nonetheless acknowledge this limitation and propose to account for it in future studies.

Second, many vaccination sites include a second waiting room for a brief (15 min) medical observation of vaccinated subjects. This element could be implemented into the system, as well as, for instance, considering doctor's room and nurses' room as separate units and studying queues forming up to each of them, with the use conjoint probability. We refer to the topic of Markovian network processes (30) for further study on this matter.

Third, there is plenty of literature that implements Queueing theory and other techniques to reduce appointment scheduling variability (7–13). However, these techniques have not yet been diffusely adopted in common vaccination practice worldwide and, therefore, our use of Queueing theory directly on determination of a proper arrival rate might prove all the more useful or, at least, represent a starting point for new techniques' implementation. As anticipated, Hanly et al. make ample use of it in modeling the entirety of vaccination sites (2). We furthermore stress the utility of this technique in giving specific indicators by which both safety and performance analysis can be performed on vaccination sites already in use, without the need for recording every activity's parameter, giving thus the chance for optimization. For instance, without the need for recording our waiting queue length throughout the activity, we retrospectively acknowledge that we might have at times exceeded maximum safety length, while also being able to quantify a potential resources underuse of 1.4% with only the electronically recorded distribution of arrival rate as a starting point.

CONCLUSIONS

"Queueing theory" has been mostly applied in healthcare (18) to enhance the performance of operating rooms (16), outpatients settings waiting times (9) and hospital bed management (31). It is starting to be applied to vaccination campaigns as well (2, 32).

We propose the adoption of this tool by public health figures involved in vaccination practices as it enables to quantify ahead of time, using specific indicators, the outcome of organizational choices on both safety and performance of vaccination sites.

This tool can be used to develop the policy framework for improving the operations throughout healthcare and vaccination programs by catering to the requirements of specific stakeholders such as managers, professionals, and patients. Its application would in fact increase the efficiency of healthcare operations enabling managers to control costs but also adding value for both healthcare workers, who perceive the better management of their working time and modalities, and patients, who perceive the better quality of the service provided. Promoting a tool such as this one could help contribute to some of the strategies indicated by the Global Alliance for vaccines and Immunization (GAVI), as reformulated by Kamara et al. (33), such as vaccine logistics and stock management and training, improving service delivery and reducing vaccine wastage.

Further work applying Queueing theory model in vaccination as well as other healthcare settings, considering the urgency deriving from the current pandemic, is much needed. For instance, more complex evaluations connecting the outcome of organizational choices informed by queueing theory-based models on human and economic resources would be of great interest and use for the scientific literature.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

MD: conceptualization, methodology, visualization, software, and formal analysis. MD, AI, GM, AD, and RG: data curation, investigation, and writing—original draft preparation. MD and DP: validation. PL, GD, and WR: resources, supervision, and project administration. MD, GD, PL, and DP: writing—review and editing. All authors contributed to the article and approved the submitted version.

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ORIGINAL RESEARCH
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Which Matters More in Fighting COVID-19—Government Policy or Community Participation?

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Objective: As a heavily populated megacity, Shanghai faces major epidemic risks. However, Shanghai's control of COVID-19 has been successful owing to both the strict government policy and wide community participation. Here, we investigated the impact of these stakeholders and examined who played a major role across different epidemic stages.

Design: We extended the classic susceptible-exposed-infectious-recovered (SEIR) model considering the heterogeneous contact structure in four social sceneries, i.e., school, workplace, public entertainment venues, and neighborhood community, which could reflect the impact of lockdown policy and wide participation of residents happened at the community level.

Result: The simulation results showed that without lockdown policy and only with community participation, the daily new confirmed cases would gradually increase to more than 7,000 [292/1,000,000] at the end of Sep. However, without community participation and only with a lockdown policy, the daily new confirmed cases sharply decreased to 30 [1.2/1,000,000] at the end of the 1st month and remained low for several months. However, when a lockdown policy was gradually lifted, the new confirmed cases increased exponentially, eventually reaching more than 17,000 [708/1,000,000]. Therefore, a government lockdown policy was necessary for the rapid control of COVID-19 during the outbreak stage while community participation is more important in keeping the number of new confirmed cases low during the reopening stage.

Conclusion: Government lockdown policy and community participation play different roles in the control of COVID-19 at different stages of the epidemic: although the government played a leading role in setting up policies, the broader participation of community fever clinics (CFCs) and the general public were especially crucial in winning the battle against COVID-19 in the long run.

Keywords: lockdown, COVID-19, system dynamics, SEIR model, community participation

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INTRODUCTION

China experienced the outbreak of COVID-19 in January 2020 that started in Wuhan and then spread to other cities. With 24–28 million permanent residents and a high population density, Shanghai was considered at high risk for epidemic spread (1). However, Shanghai performed surprisingly well-in terms of controlling the spread of COVID-19. In the first month of the epidemic (from 20 January to 19 February 2020), Shanghai confirmed a total of 346 new daily confirmed cases, of which around 255 were infected locally. The locally infected new confirmed cases peaked at 24 on 2 February 2020 and then gradually decreased, approaching zero at the end of the first month of the epidemic. In the following 8 months (20 February−19 October 2020), only 10 new confirmed cases were infected locally (2).

Many factors helped to prevent and control COVID-19 in Shanghai. At the government level, a series of policies were issued soon after the identification of the first confirmed case of COVID-19 in Shanghai. A workplace lockdown and a ban on public gatherings were implemented; these policies were not reversed until 11 February 2020. All schools were closed in March 2020 and then gradually reopened from 26 April 2020. Universities remained closed until the fall semester, and all courses were delivered online until the universities reopened (3). Public entertainment venues, such as cinemas, theaters, Internet cafes, and gyms, were also closed (see **Figure 1**). A quarantine of people arriving in Shanghai was another important policy implemented by the government (4). The lockdown and reopening timelines are displayed in **Figure 1**.[1]

At the same time, a great deal has been done at the community level to combat COVID-19 in Shanghai (5, 6). The concept of community participation in health was formally articulated by the World Health Organization (WHO) at Alma Ata in 1978 to achieve the "Health for All" strategy, acknowledging that primary care is a key component of local involvement in community participation (7). Community health service centers (CHSCs) are the primary healthcare institutions in urban China. CHSC general practitioners (GPs) conducted daily checks of the physical well-being of residents who were self-isolating at home. In addition, community fever clinics (CFCs) were established in CHSCs after the outbreak of COVID-19, which helped with the prompt identification of patients with suspected fever symptoms, the rapid isolation of suspected patients, and the transfer of patients to nearby large general hospitals with greater diagnosis and treatment capabilities. GPs and neighborhood committees, and residents actively participated in fighting COVID-19, such as through epidemiological investigation and vaccination mobilization (8). Moreover, residents voluntarily changed their behavior, such as reducing travel plans for the Spring Festival, wearing masks when going out, having online meetings and communication, using online shopping, staying home rather than gathering, and socializing in the community even for the elderly (9, 10).

In sum, the effective control of the COVID-19 epidemic in Shanghai was possible because of all the abovementioned efforts from both government policies (11). and community participation of CFCs, Neighborhood Committee, and residents (12–14). However, as most existing studies analyzing the prevention and control intervention measures implemented in China have used qualitative methods, describing what has been done, at what time, and with what impact (5, 15, 16), several questions need to be further addressed, such as What is the impact of each stakeholder on controlling COVID-19? Who played a major role at each stage of the epidemic? Is there a shift of dominant role across different stages of the epidemic? In the present study, we used a modeling approach to quantitatively investigate the impact of these stakeholders on the control of COVID-19.

MATERIALS AND METHODS

Model Construction

We developed a system dynamics model based on the classic susceptible-exposed-infectious-recovered (SEIR) model (17), which reflects the spread of a virus through contact and transmission between four groups of individuals: *S* (the susceptible), *E* (the exposed, which refers to the infected population without symptoms, especially during the incubation period), *I* (the infected, which refers to the infected population with symptoms), and *R* (the removed that includes the recovered and died population). Several extensions to this model are made, as shown in **Figure 2**. First, to comply with the track, trace, and quarantine policy in Shanghai, we extended the model to include *Sq*, *Eq*, *Iq*, and *Rq*, representing the quarantined groups of *S*, *E*, *I*, and *R*. Second and more importantly, we further disaggregated the model into four social scenarios—schools, workplaces, public entertainment venues, and neighborhood communities (18), within which the contact rate changed according to the mandatory lockdown policy issued by the government for the first three and according to voluntary behavior change in the general public for the last.

Model Structure

As the quarantined and hospitalized population cannot contact other people, the total population contacting others in each scenery, N_i, can be represented as $N_i = S_i + E_i + I_i + R_i + Rq_i$. The transmission of the COVID-19 happens when *S* contacts *E* or *I*. However, not all people are contagious during the incubation period. Suppose θ percent of E are infectious. All *I* are contagious, but many are isolated at CFCs. Suppose μ percent of *I* are kept in isolation. The only source of infection is then $\theta E + (1 - \mu) \times I$. Given that *c* as the contact rate and β as the infectivity, the transmission of S to E is $(\theta Ei + (1 - \mu) \times I) \times (S/N) \times \beta c$. The track, trace, and quarantine approach can only trace close contacts of confirmed cases. With q percent of infected people being quarantined, the transmission of E to Eq is $(1 - \mu) \times I \times$

[1]All the detailed information is collected from the Weibo (microblog) account of the Information Office of Shanghai Municipality at https://weibo.com/u/2539961154. This account is used by city authorities for releasing official information. Updates of COVID-19 intervention and prevention policies were all published on this account.

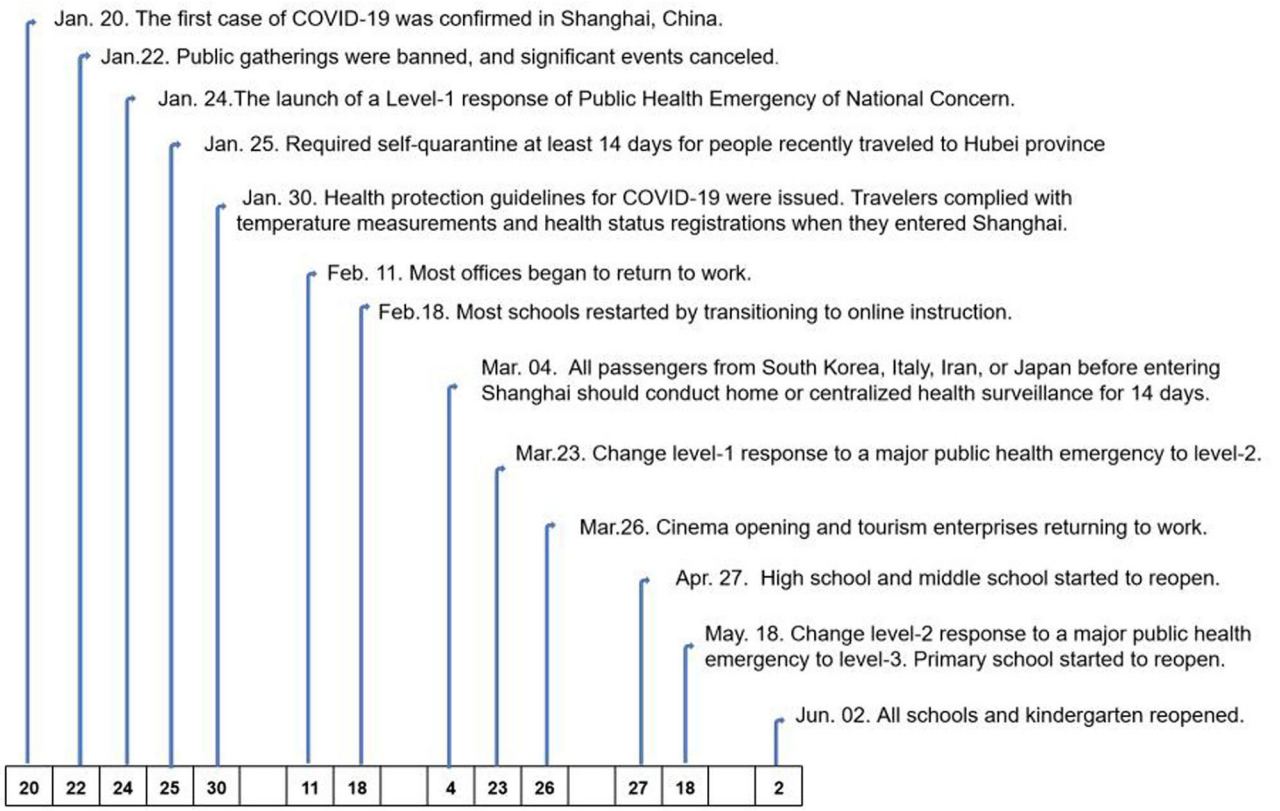


FIGURE 1 | Lockdown and reopening timeline.

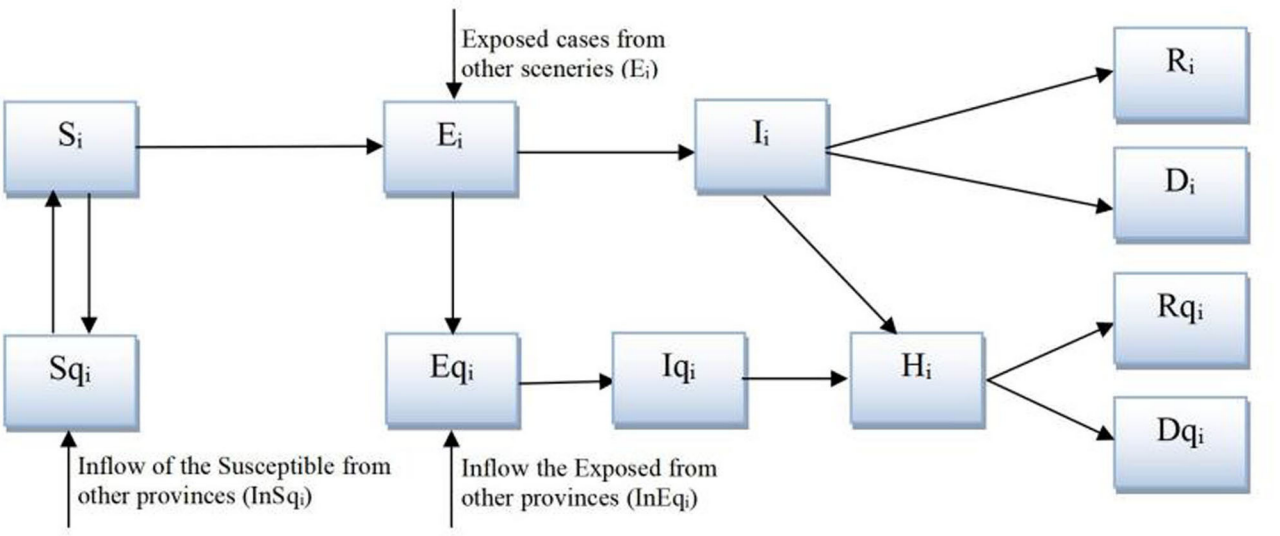


FIGURE 2 | The extended susceptible-exposed-infectious-recovered (SEIR) model.

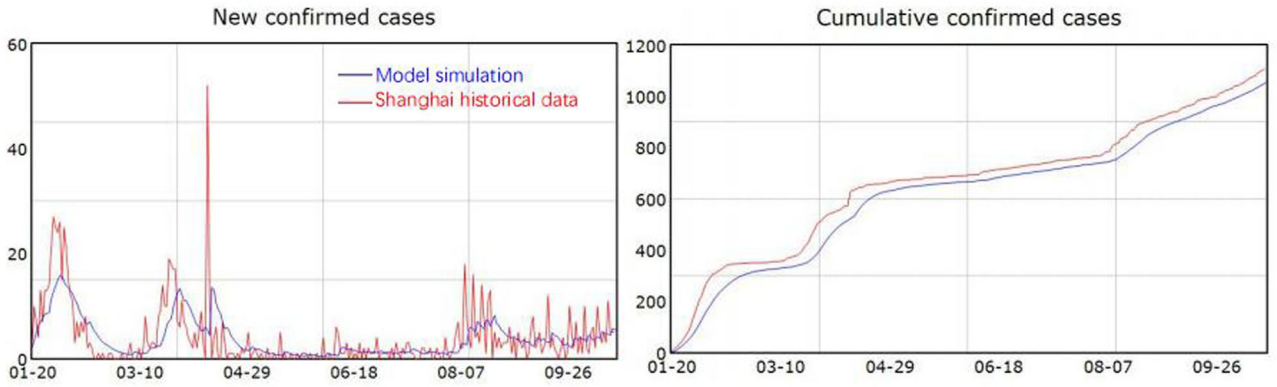


FIGURE 3 | Simulation results and historical data.

(S/N) × βcq, and the transmission of S to Sq is (1 – μ) × I × (S/N) × (1 – β) × cq.

Therefore, the model can be represented as follows:

$$S_i = S_{i0} + \int_0^t (Sq_i/T1 - ((1-\mu)I_i + \theta E_i)\beta c_i S_i/N_i - (1-\mu)I_i(1-\beta)c_i q S_i/N_i)dt \quad (1)$$

$$Sq_i = Sq_{i0} + \int_0^t ((1-\mu)I_i(1-\beta)c_i q S_i/N_i - Sq_i/T1 + InSq_i)dt \quad (2)$$

where T1 is the duration of quarantine;

$$E_i = E_{i0} + \int_0^t ((1-\mu)I_i(1-\beta)c_i(1-q)S_i/N_i + \theta E_i \beta c_i S_i/N_i - E_i/T2 + E_j)dt \quad (3)$$

$$Eq_i = Eq_{i0} + \int_0^t ((1-\mu)I_i(1-\beta)c_i q S_i/N_i - Eq_i/T2 + InEq_i)dt \quad (4)$$

where T2 is the average incubation period;

$$I_i = I_{i0} + \int_0^t (E_i/T2 - I_i/T3 - \alpha_I I_i - \gamma_I I_i)dt \quad (5)$$

$$Iq_i = Iq_{i0} + \int_0^t (Eq_i/T2 - Iq_i/T3)dt \quad (6)$$

$$H_i = H_{i0} + \int_0^t (I_i/T3 + Iq_i/T3 - \alpha_H H_i - \gamma_H H_i)dt \quad (7)$$

where T3 is the waiting time to be admitted to the hospital, which is affected by testing capacity and hospital facility availability;

$$R_i = R_{i0} + \int_0^t (\gamma_I I_i)dt \quad (8)$$

$$D_i = D_{i0} + \int_0^t (\alpha_I I_i)dt \quad (9)$$

$$Rq_i = Rq_i + \int_0^t (\gamma_H H_i)dt \quad (10)$$

$$Dq_i = Dq_i + \int_0^t (\alpha_H H_i)dt \quad (11)$$

where γ_I and γ_H represent the recovery rates of I and H, respectively, and α_I and α_H represent the death rates of I and H, respectively.

The parameter settings were in line with previous literature (19–21), and the detailed information is presented in **Appendix 1**.

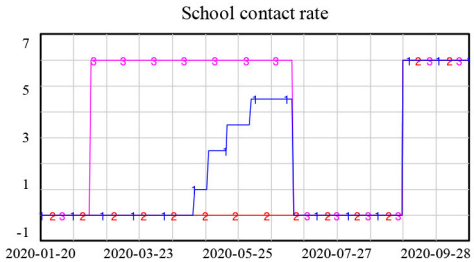
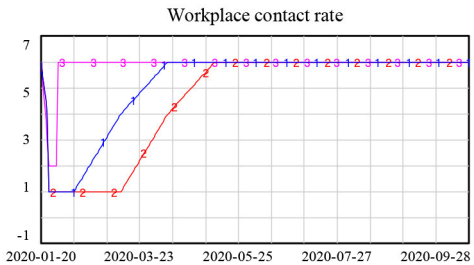
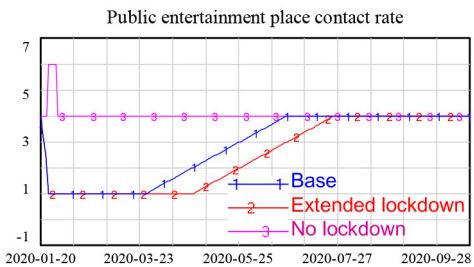
Model Validation

The model was constructed in Vensim 8.0.9. The model simulates the progression of COVID-19 in Shanghai over the 9-month period from 20 January 2020, when the first case of COVID-19 appeared in Shanghai, to 19 October 2020, long after the COVID-19 outbreak in Shanghai had declined. The SEIR model has been widely used for investigating COVID-19 (17, 18, 22), suggesting that the model structure is valid. The model parameter setting is mostly referred to previous literature (19–21). We compared the model simulation results with historical data published daily on the website of the Health Commission of Shanghai. As shown in **Figure 3**, the simulated new confirmed cases and cumulative confirmed cases fit well-with the historical data, which increases confidence in the model.

RESULTS

Using the model, we focused our investigation on the effectiveness of the lockdown policy and community

TABLE 1 | Heterogeneous contact rate under lockdown policies.

Contact rate setting	Explanation
	**1. Base (Actual):** school contact rate remained 0 until April 27th and gradually increased. After summer holiday, it reached normal level. **2. Extended lockdown:** school contact rate remained 0 until Sep and then it returned normal level. **3. No lockdown:** school contact rate was 0 for winter and summer holiday, otherwise, it remained normal level.
	**1. Base (Actual):** Workplace contact rate reduced to low level until February 11th and gradually returned to normal rate in 2-month time. **2. Extended lockdown:** workplace remained lockdown for one more month compared to Base scenario. **3. No lockdown:** workplace contact rate reduced to low level during Spring Festival and returned to normal soon afterward.
	**1. Base (Actual):** public place contact rate reduced at low level until Feb 11 and gradually returned to normal rate in 3-month time. **2. Extended lockdown:** public place remained lockdown for one more month compared to Base scenario. **3. No lockdown:** public place contact rate increased during Spring Festival and returned to normal soon afterward.

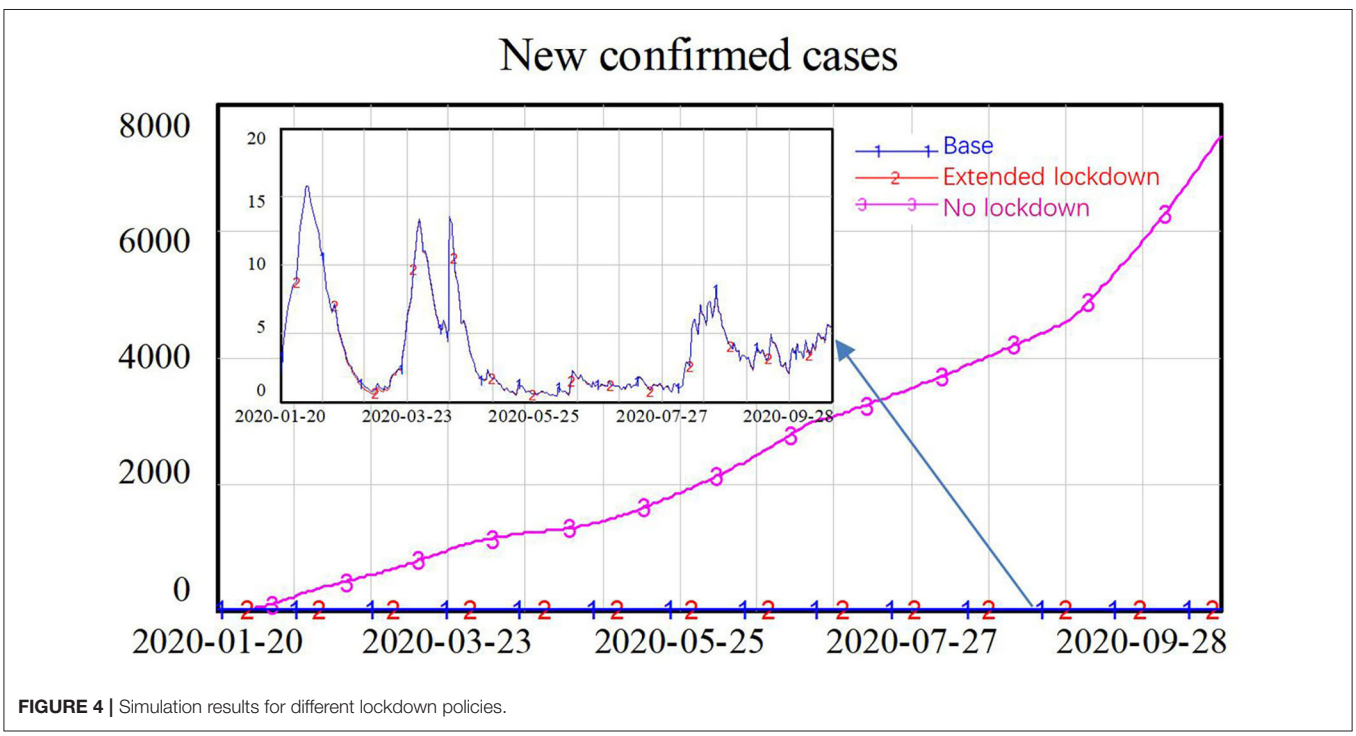


FIGURE 4 | Simulation results for different lockdown policies.

participation in the fight against COVID-19 in Shanghai. The lockdown policy mainly changes the contact rate in schools, workplaces, and public entertainment venues. Community participation mainly includes residents' behavior changes in terms of reducing the contact rate in the neighborhood community and the enhancement of CFCs to cut the chain of infection as early as possible.

Scenario 1: The Effectiveness of Lockdown Policies

Lockdown policies are included in the model through changes in the contact rate in different scenarios, as shown in **Table 1**.

The simulation results showed that the lockdown policy is effective in controlling the spread of COVID-19. Without a lockdown policy, the number of new confirmed cases gradually increased over time, approaching 8,000 new confirmed cases at the end of the simulation. However, a long period of lockdown is not necessary. After the number of new confirmed cases reached a low level in February, an extended lockdown had little impact on future numbers of new infections, as shown in **Figure 4**.

TABLE 2 | Parameter setting for isolation of the infected population with symptoms at community fever clinics (CFCs).

CFC 100	Effectiveness of fever clinics = 0.6+step (0.4, 13)
CFC 80	Effectiveness of fever clinics = 0.4+step (0.4, 13)
CFC 60	Effectiveness of fever clinics = 0.2+step (0.4, 13)
CFC 40	Effectiveness of fever clinics = step (0.4, 13)

Scenario 2: The Effectiveness of CFCs

After the outbreak of COVID-19, CFCs were additionally established to help identify and isolate suspected patients at the community level and to transfer these patients to nearby large general hospitals for further treatment. We assumed that the fever clinics could isolate 60% of the infected population under normal conditions, and we increased this by 40 percentage points during the COVID-19 epidemic, reaching 100% isolation of the infected population with symptoms. We also simulated another three scenarios assuming the fever clinics could only isolate 40, 20, and 0% of the infected population under normal conditions, yielding estimates of 80, 60, and 40% isolation rates during the COVID-19 pandemic, as shown in **Table 2**.

The CFCs play an important role in fighting COVID-19. As shown in **Figure 5**, when the percentage of the infected population with symptoms (I) being isolated is at the low level of 40%, the number of new confirmed cases increased exponentially, approaching 6,000 at the end of the simulation. When 60% of the infected population with symptoms could be isolated, the number of new confirmed cases were declined to around 150. When more than 80% of the infected population could be isolated by the CFCs, there were only around 10 new confirmed cases, and the spread of the virus was well-controlled.

Scenario 3: The Effectiveness of Residents' Behavior Changes

To help control the spread of the virus, residents in Shanghai changed their behaviors to reduce the contact rate in neighborhood communities. In the absence of the COVID-19 epidemic, people in Shanghai customarily participate in

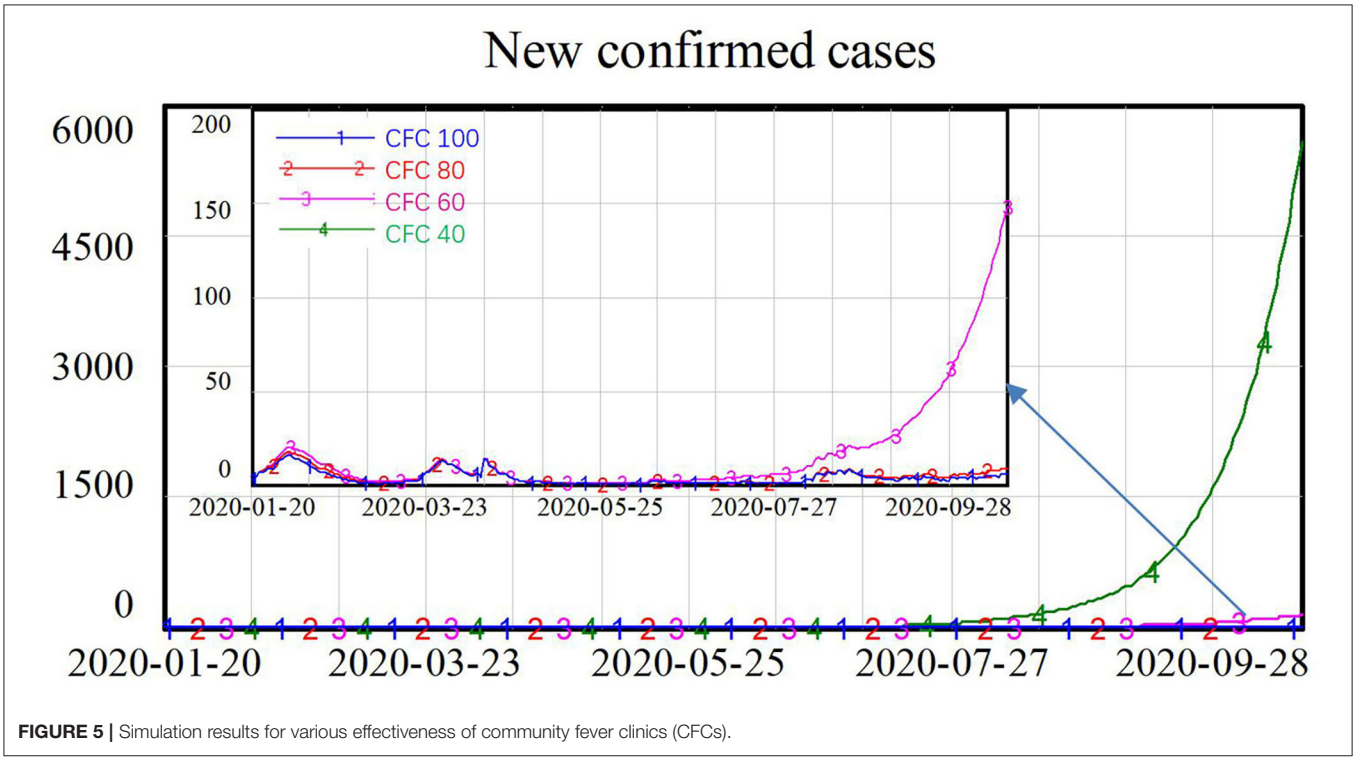


FIGURE 5 | Simulation results for various effectiveness of community fever clinics (CFCs).

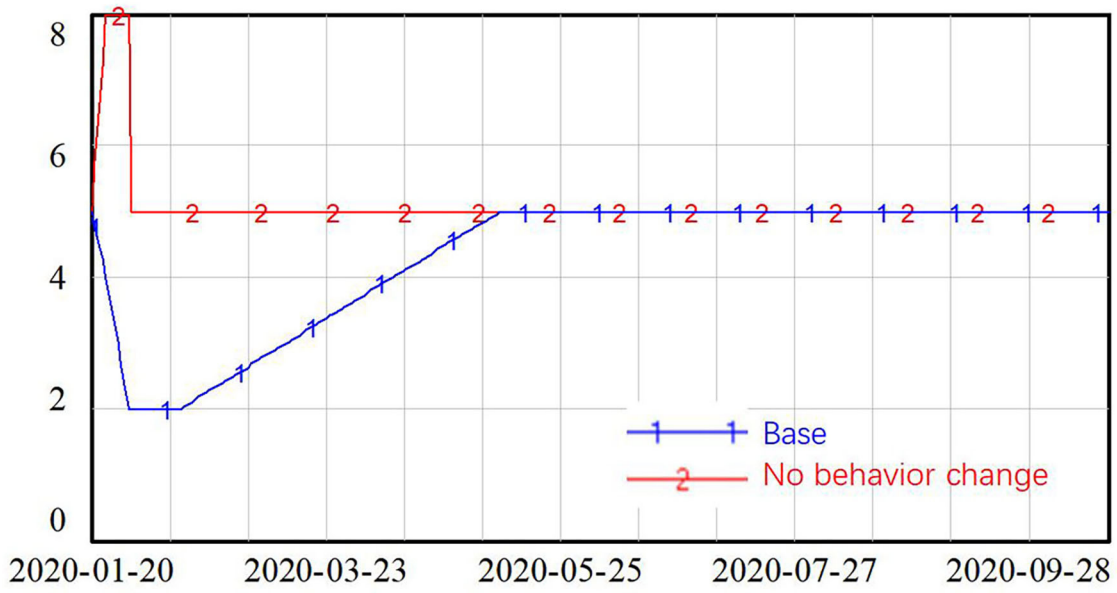


FIGURE 6 | Simulation setting for contact rate at neighborhood community.

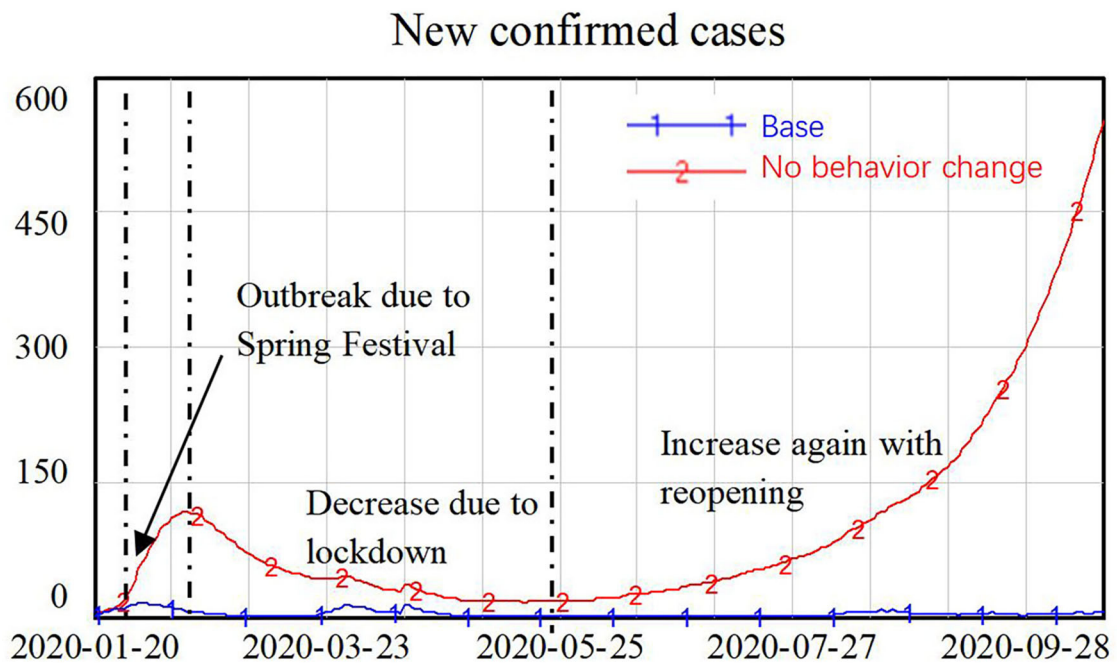


FIGURE 7 | Simulation results with and without residents' cooperation in terms of behavior change.

many social gatherings during the Spring Festival, reuniting with family members and friends. However, during the Spring Festival periods in 2020 and 2021, most people stayed at home and got in touch with their family members and friends online. Two situations were tested, which are as follows: the base scenario presents the real situation where people reduced their contact with others in January and February 2020 and then gradually increased to their normal level in May 2020. The other situation considered was that of no behavior change on the part of residents—here, the contact rate was set to increase by 60% during the Spring Festival and then decline back to the normal level after the holiday, as shown in **Figure 6**.

The simulation results in **Figure 7** shows that without behavior changes on the part of the general public, the number of

TABLE 3 | Scenario setting for only lockdown and only community participation.

Scenarios	Contact rate at school	Contact rate at workplace	Contact rate at public venues	Contact rate at neighborhood	Effectiveness of CFC
Base	Reduced	Reduced	Reduced	Reduced	0.6+ step (0.4, 13)
Only lockdown	Reduced as base	Reduced as base	Reduced as base	No behavior change	0.6
Only community participation	No change	No change	No change	Reduced as base	0.6+step (0.4, 13)

new confirmed cases first peaked during the Spring Festival, when people were gathering with family members and friends. The number of new confirmed cases then declined after the Spring Festival, with the lockdown policy in place, but it then increased again with the reopening of the economy. Exponential growth in new confirmed cases was identified in this simulation, with the number of new confirmed cases reaching around 500 people at the end of the simulation.

Scenario 4: Government Lockdown Policy vs. Community Participation

Besides the base scenario representing the actual situation that happened in Shanghai, other two scenarios were simulated: first, only government lockdown policies were implemented, without enhanced CFC intervention or behavior change of the general public; second, with only community participation, i.e., enhanced CFC intervention and resident's behavior change, but no government lockdown policy. The parameter setting is presented in **Table 3**.

From the simulation results in **Figure 8**, we can see that with only the lockdown policy, the number of new confirmed cases declined to a very low level during the first several months of the COVID-19 epidemic as a result of reductions in the contact rates through schools, workplaces, and public entertainment venues. However, after the reopening, contact rates gradually returned to normal levels in the absence of community participation, in the long run, the number of new confirmed cases increased exponentially, reaching 17,000. In contrast, with only community participation and no lockdown policy, the number of new confirmed cases continued to increase slowly over time. Even when residents changed their behavior such that contact in neighborhood communities was reduced and the CFCs effectively identified and isolated 80% of infected patients, it was not possible to eliminate the virus because people in the incubation period could still spread the virus in schools, workplaces, and public entertainment venues. The number of new confirmed cases increased almost linearly, reaching around 7,500 at the end of the simulation.

DISCUSSION

Government lockdown policy and community participation have different impacts on the control of COVID-19 at different stages of the epidemic.

The outbreak stage will be controlled if a strict lockdown of workplace, schools, and public entertainment places have been implemented for 2 weeks, as most COVID-19 cases have an incubation period of <14 days and most people who were during the incubation period will develop symptoms in this lockdown period and then be isolated by a CFC or quarantined in a hospital (23, 24). This approach would reduce the sources of infection to a very low level and limit further infections, getting the epidemic under control in a short time frame. A longer lockdown will have little impact on the control of COVID-19 with the longer lockdown. Considering the major social and economic costs of lockdowns (25, 26), reopening at the earliest possible stage should be a preferred policy. However, reopening would increase the contact rate, which may lead to another increase in the number of new infections (24). Many countries have witnessed the second and third waves of the COVID-19. For example, a study of the first and second waves of the COVID-19 pandemic in Africa showed that a large portion of the African countries experienced a second wave after the loosening of public health and social measures, such as canceled public events, closed public transport, and international travel controls (27).

Facing this challenge, community participation is the key factor for keeping COVID-19 under control at this later stage. In Shanghai, CFCs are housed within CHSCs, which are the main primary care institutions. Shanghai was among the first cities to implement China's General Practice System—the key target of the country's new healthcare reform (28), and after the 10-year fundamental construction of the General Practice System, 225 CFCs were able to be established in a very short period in Shanghai. These CFCs were distributed near or right in the residential communities (29), thus CFCs can help to identify patients earlier once the suspected patients visited CHSC and to promptly isolate them at the community level to keep the spread of the virus as low as possible. CFCs treated patients with a fever in separate clinics, preliminary diagnosed suspected patients with COVID-19 through epidemiological investigation or acid-based diagnostic tests (some CFCs were able to perform such tests), and helped to transfer suspected patients to nearby hospitals. It is undeniable that CFCs played an important role in screening at-risk patients and cutting the infection chain after loosening the lockdown policies.

Besides the contribution of CFCs, neighborhood committees and residents' participation have also been critical for the control of the COVID-19 epidemic. The positive responses at the personal respective include wearing masks when going out, reducing visits and gatherings, and using the Internet for shopping and meetings (30, 31). People in Shanghai were also actively engaged in the anti-epidemic movement and

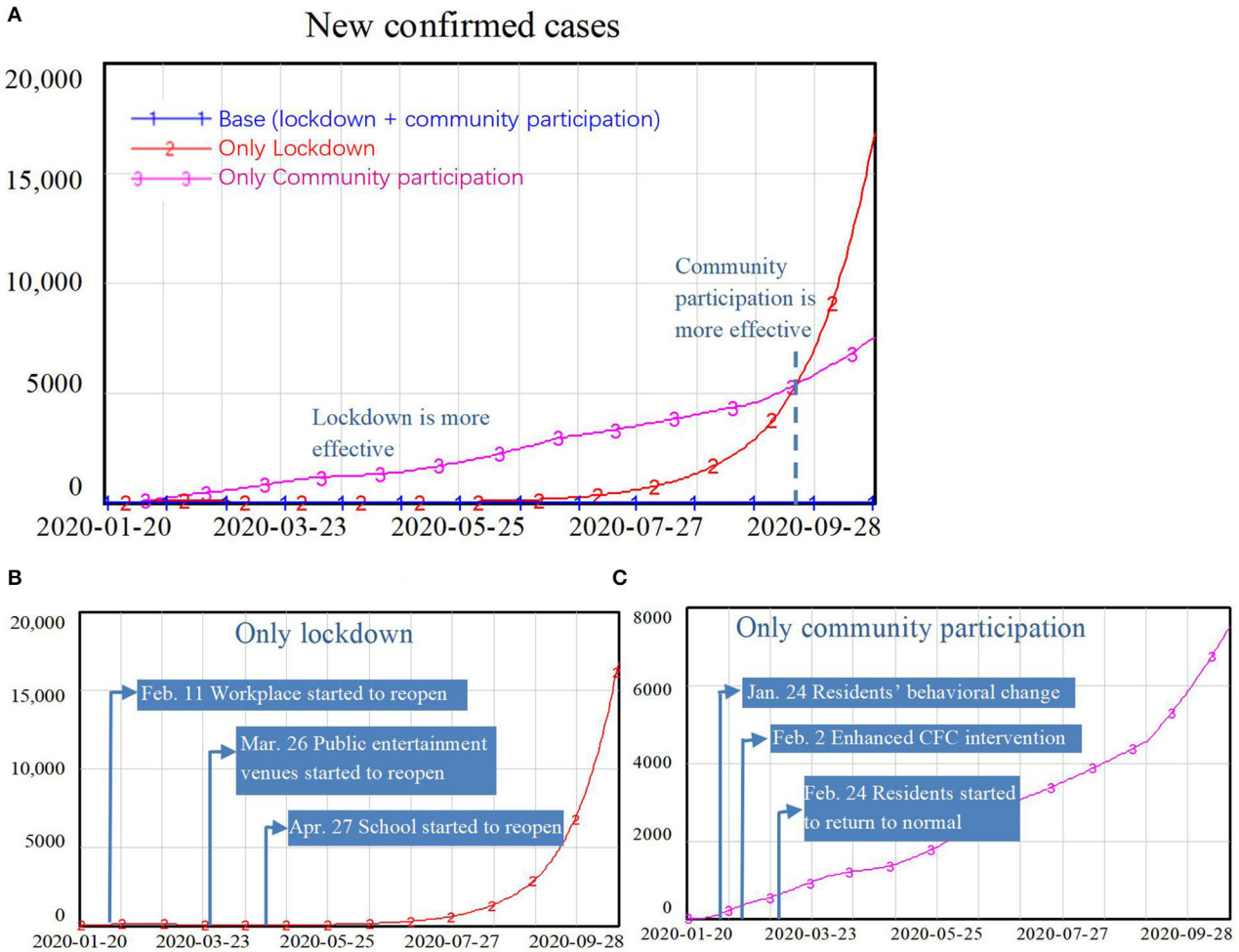


FIGURE 8 | Simulation results comparing the effects of lockdown policy and community participation: part **(A)** compares the only lockdown scenario with only community participation scenario; part **(B)** represents the lockdown scenario only; and part **(C)** represents the community participation scenario only.

even participated in community management as volunteers, such as measuring temperatures as gatekeepers at community entry points, assisting with the epidemiological investigation and information collection for inflow population from other provinces, and participating in vaccination promotion (32). All these activities directly reduced the contact rate and source of infection, which served to cut the chain of infection (33, 34).

CONCLUSIONS

This research was built on a system dynamics model with a heterogeneous contact structure to investigate the impact of government policy, especially lockdown of school, workplace, and public entertainment venues, and the impact of community participation, especially CFC and residents' protective behavior, on the control of COVID-19. Simulation results illusted that without lockdown policy the daily new confirmed cases would gradually increase, reaching more than 7,000 [292/1,000,000] at the end of simulation. While without community participation, the daily new confirmed cases would sharply decrease in the first month but increase exponentially when the lockdown policy was lifted. This result implied that the broader participation of the community was especially crucial in winning the battle against COVID-19 in the long run, though the government lockdown policy played a dominant role in the outbreak stage of the epidemic. This result may not apply to places with different social mixes, such as rural areas. Further research on changing model structure and parameter setting is needed for places with the different social mixes. However, for most cities, with a large portion of the working population and many schools, wider participation from the community level for reduced contact and early identification and isolation of infected patients could help limit the spread of COVID-19 after the resume of normal life.

DATA AVAILABILITY STATEMENT

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

AUTHOR CONTRIBUTIONS

YQ and JH were involved in literature search, study design, data collection, model building, result analysis and interpretation, and writing. LZ, SC, and IC were involved in the literature search, result analysis and interpretation, and writing. LX and QZ were involved in literature search, data collection, and result analysis. All authors contributed to the article and approved the submitted version.

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SUPPLEMENTARY MATERIAL

The Supplementary Material for this article can be found online at: https://www.frontiersin.org/articles/10.3389/fpubh.2022.927553/full#supplementary-material

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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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Methodology for designing intrahospital transportation of patients with suspected infectious disease that limits infection spread risk in China

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Aims: The transport of patients suspected of having COVID-19 requires careful consideration. Using paths selected at random and not accounting for person flow along the path are risk factors for infection spread. Intrahospital transportation (IHT) protocols and guidelines should be used to help reduce the risk of secondary virus transmission during transport. This study aimed to propose optimal IHT for patients with an infectious disease presenting in an out-patient area.

Design: The map of a West China Hospital was used. We also used field investigation findings and simulated person flow to establish pathway length and transportation time. We identified three optimum pathways and estimated safety boundary marks, including a patient transportation border (PTB) and safety transportation border (STB). Finally, IHT, PTB, and STP formed a virtual transport pipeline (VTP) and a traceable IHT management system, which can generate a virtual isolation space.

Results: The three pathways met efficiency, accessibility, and by-stander flow criteria. No facility characteristic modification was required.

Conclusions: Using virtual models to identify pathways through out-patient hospital areas may help reduce the risk of infection spread.

KEYWORDS

intrahospital transportation, virtual transfer pipeline, virtual-barrier space, out-patient area, COVID-19

Introduction

Globally, 11% of patients with coronavirus disease 2019 (COVID-19) required admission to an intensive care unit (ICU) and 18% developed acute respiratory distress syndrome, requiring admission to hospitals that provide higher levels of care (1, 2). Intrahospital transportation (IHT) is among the most frequently performed tasks

involving hospitalized patients (3–5). Previous studies have proposed various IHT strategies, focusing on transportation methods that help reduce infection risks. Risk management in this context requires that the transport is well-organized, efficient, and accompanied by suitable monitoring, equipment, and personnel (6), and that applicable protocols and guidelines are followed (7, 8). These protocols should account for personnel and by-stander safety.

Previous studies have shown that suitably equipped teams can ensure IHT that is safe to both patient and team (1, 9); however, these studies tended to focus on enclosed and well-equipped areas such as an ICU and neglected out-patient areas, which include open environments and a flow of by-standers and personnel that increase infection risk, making patient transport challenging (9).

Herein, we aimed to examine the safety of IHT for patients suspected of having COVID-19 in out-patient areas. In the clinical practice, although the personnel and equipment involved in IHT are planned, the path tends to be chosen at random, thus increasing the risk of infection spread among the people present along the path.

This study aimed to develop an IHT protocol for patients suspected of having COVID-19, focusing on limiting the risk of infection spread. We used the West China Hospital as a simulation model. The site is a university-affiliated medical center and contains almost 4,000 beds with an annual out-patient load of 5 million. The team included physicians, nurses, and engineers, tasked with evaluating the safety issues surrounding the IHT of patients suspected of having COVID-19. Having identified an optimal IHT pathway, we designed a virtual transport pipeline (VTP) network to generate a virtual path that contains an isolation space, forming a traceable IHT management system. VTP-based IHT may help improve patient and personnel safety, particularly in out-patient areas.

Methods

The structure of a hospital is complex, making the development of evacuation plans challenging. Conducting evacuation drills helps test the applicable strategies; however, drills are difficult to conduct in a healthcare context. Thus, evacuation simulations are more feasible and may help improve safety. Models such as Building-Exodus and Pathfinder can help simulate hospital evacuation scenarios (10, 11). In this study, to define the virtual space and barrier parameters, we developed a VTP network. Thermodynamic analysis in Pathfinder (Version 2019.1.0508 x64, Thunderhead Engineering Inc. USA) was used to identify the shortest path distance and minimum human flow during transportation (12). Parameters including time, distance, access ways, and people flow were considered in the simulation. Based on the optimal VTP, we defined the patient transportation border (PTB) and safety transportation border (STB), which represented safety boundaries.

Results

Transportation time

We investigated whether the fastest pathway was the best pathway by using simulation software (parameters: non-interference situation, corridor width, and elevator size) (Figure 1). According to the simulation, 20 persons were placed at the start position (SP) on the third floor (respiratory clinic area); the remaining areas had no persons, including the end position (EN) on the first floor (isolation area). Two optimal paths were found. The two paths involved the use of two staircases (ST1.1/1.3 and ST2.1/2.3). The average time from the SP to the EN was approximately 150–204 s. However, these paths were not isolated from other paths in the considered areas; consequently, the number of potential contacts during IHT remained uncontrollable. Transportation time is only one parameter that should be considered in this context. Other parameters such as the optimal path, should be accounted for in future simulations.

Pathway analysis

Flow distributions on the first and third floors were simulated. The main entrances, lobby corridor, elevators, and exits had a relatively dense flow distribution (Figure 2A). This simulation supports route selection, based on the likely number of contacts along the path.

To simulate scenarios that approximate real-world situations, we included data on the opening/closing of entrances/exits, to understand their impact on crowd evacuation (Figures 2B–E). Firstly, evacuations were quick when all entrances and exits were open (Figure 2B). Secondly, closing gates 5, 6, and 7 created some congestion points, particularly at gates 1, 2, and 4 (Figure 2C). Furthermore, the evacuation capacity of gate 7 was comparable to those of gates 5 and 6 (Figures 2D,E). Keeping gate 7 rather than gate 1 open was more beneficial for easing congestion, followed by gates 4 and 2. These findings suggest that gate 7 has a greater evacuation capacity than the other gates and that it may be useful during an evacuation and a trans-shipment. In addition, these findings indicate that, given the random nature of human flow in out-patient areas, protocols, design, and opening/closing relevant access points may improve the evacuation efficiency.

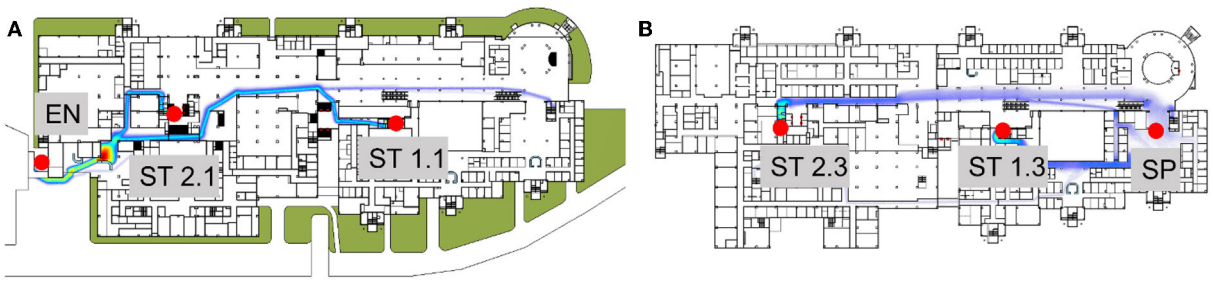

FIGURE 1
Transportation time from an outpatient to an isolation area with no limitations. According to the simulation, from the start point, patients could be transported though SP–ST1.3–ST1.1–EN or SP–ST2.3–ST2.1–EN. **(A)** First floor; **(B)** Third floor. EN, end position/Isolation area; SP, Start point.

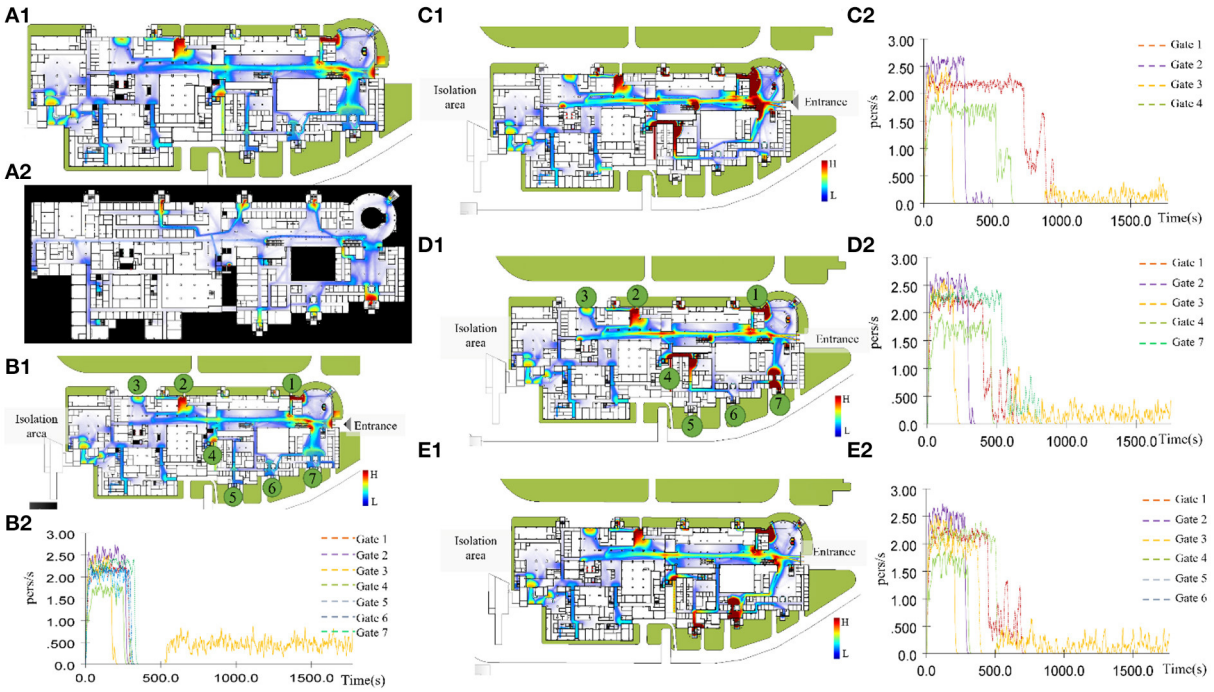

FIGURE 2
Simulation of flow distribution on the first and third floors, under daily conditions. **(A)** The main entrances, lobby corridor, elevators, and exits had a relatively dense flow distribution; **(B)** All entrances and exits open; **(C)** Entrances no. 5/6/7 and exits closed; **(D)** Entrances no. 5/6 closed and entrance no. 7 open; **(E)** Entrances no. 5/6 open and entrance no. 7 closed.

VTP pathway design

To investigate risk distribution differences among the different pathways, we considered field investigation findings, corridor width, and elevator size, arriving at three candidate paths (Figures 3A1–C1):

- Pathway no. 1 began near the stairs at the SP, giving the patient stair access from the third to the first floor; the patient arrived at the EN *via* an outdoor walkway. This path included mostly outdoor areas and a short indoor path.
- Pathway no. 2 began near an indoor walkway at the SP, giving the patient access to elevator E2 in the middle of a third-floor outpatient area, and stair access from the third to first floor; finally, the patient continued on an outdoor walkway to the EN. Approximately 50% of this path was inside the hospital.
- Pathway no. 3 began near the stairs at the SP, giving the patient access to elevator E1 near the SP, leading from the

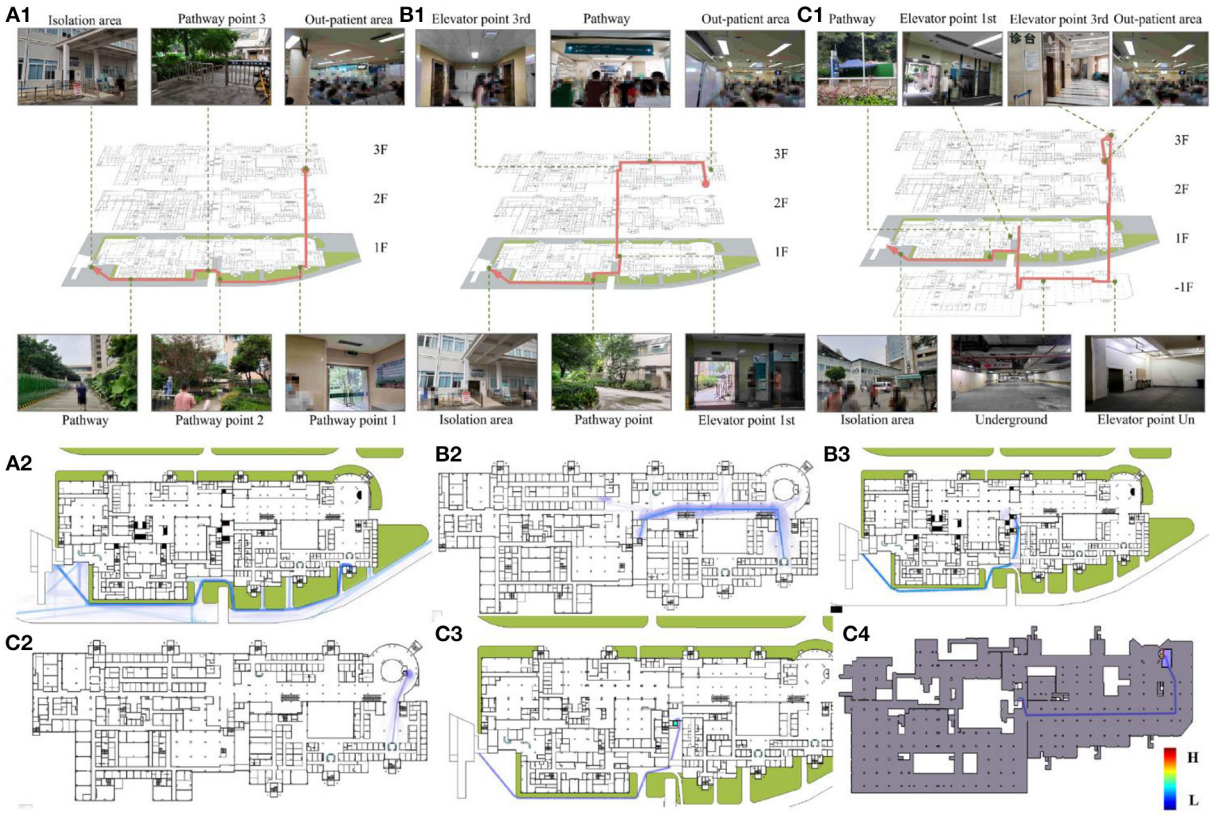

FIGURE 3
Three candidate pathways were designed, and transportation time and flow rate were simulated per pathway. Path no. 1 was accessible by stairs and an outdoor walkway **(A1)**; the time required to move from SP to EN was 190–263 s and the number of potential contacts was in the range 85–115 **(A2)**. Path no. 2 was accessible from an indoor walkway, elevator, and outdoor walkway **(B1)**; the time required to move from SP to EN was 220–296 s and the number of potential contacts was in the range 150–200 **(B2,B3)**. Path no. 3 was accessible by elevator E1, basement, elevator E2, and an outdoor walkway **(C1)**; the time required to move from SP to EN was 285–390 s and the number of potential contacts was in the range 80–110 **(C2–C4)**.

third floor to the basement; then, elevator E2 led from the basement to the first floor, where the patient walked down an outdoor walkway to the EN. Most of this path went through an underground parking lot.

During the simulations, we obtained transportation times and flow rates for all three paths, and placed five by-standers at the SP. The times required to move from the SP to the EN were 190–263 s, 220–296 s, and 285–390s for paths 1, 2, and 3, respectively, including the number of potential contacts in the ranges 85–115, 150–200, and 80–110, respectively (Figures 3A2,B2,B3,C2–C4).

Safety distance boundary

We also developed a contingency plan. To establish a virtual parclose, a safety distance boundary was designed along the VTP pathway, which was used to standardize the PTB (red) and STB (yellow) (Figure 4). When the contingency plan was activated, the COVID-19 patient was transported along the PTB and by-standers were asked to keep away from the STB. The distance between the PTB and STB was 50.0 cm on each side.

In this study, different routes were identified, each with advantages and disadvantages. Based on efficiency, accessibility, and the number of potential contacts, path no. 2 emerged as the superior path in this simulation, followed by path no. 1.

Discussion

IHT refers to moving a patient from one location to another within a hospital, which presents a complex logistical challenge (13). Any IHT involves six critical elements: transfer initiation request; transfer management request and information exchange; updates between transfer acceptance and patient transport; transport; patient admission and information

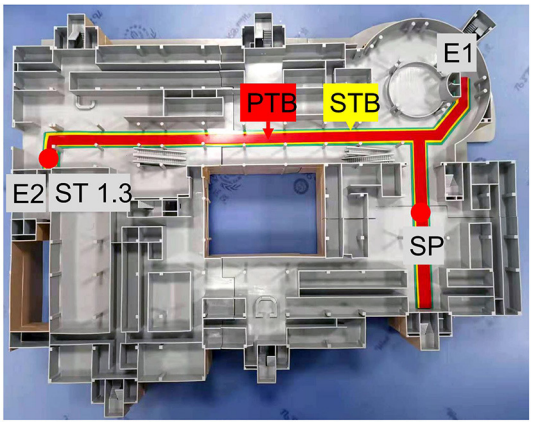

FIGURE 4
PTB and STB for the IHT model. A transportation pathway for a patient and a team member is marked in red. By-standers should be restricted to the yellow area.

availability; and measurement, evaluation, and feedback (14). In this study, we examined safe practices for IHT.

We estimated the number of potential COVID-19 patient contacts during IHT within an out-patient area. IHT is important during an infectious disease outbreak; applicable guidance requires continuous updates (15, 16) as patients may be diagnosed in an out-patient area and require admission to an ICU. A suitable IHT system helps control and prevent infection spread. However, previous studies have focused on IHT within the ICU (17, 18), reporting that adverse events during critical care transport were rare. The in-hospital mortality rate was 25%, with an extubation rate of 33.5% (19). Few previous studies have evaluated IHT for suspected COVID-19 patients (20, 21). McPherson reported that, providing that protective equipment and transport guidelines are properly used, children with COVID-19 can be transported safely with a low risk of adverse events for the patient and infection spread (20).

In contrast to previous studies, this study examined IHT in an out-patient area, which is an open environment with a large flow of people. Unlike the incidence rates for falls (22), drug dispensing errors (23), and unintended tube removal (24), those for IHT-related safety events outcomes remain unclear. Tangkulpanich proposed that hospital personnel are at an increased risk of infection, particularly during IHT, which involves close contact in a confined space without good ventilation, highlighting the need for personal protective equipment use. In addition, IHT through out-patient areas involves randomly chosen paths and many potential contacts, increasing the risk of infection spread.

The transport of patients with COVID-19 is complex and extends beyond isolation, containment, and disinfection. At the time of writing, IHT protocols for this patient group are not standardized, and recommendations for staff, perimeter size, and path traceability are unclear, resulting in an increased risk of poor outcomes. This study aimed to provide a solution for those scenarios, including a method of identifying the shortest path required, helping save time, improve traceability, and reduce applicable risks.

This study generated a virtual pipeline, which helps develop and adapt emergency transfer protocols that remain in place during outbreaks. Hospitals tend to require rapid responsiveness, which can be achieved by using the proposed model, helping reduce the risk of infection spread and improve IHT efficiency. This project presented an innovative VTP scheme. VTP is both a transfer process optimization and technology integration approach, which helps evaluate non-standardized behavior during outpatient transport, providing data-based support throughout the process; thus, the generated data may help in further IHT protocol development and in the continuous improvement of patient care.

This study had some limitations. Firstly, this was a single-center study based on an outpatient department of a West China Hospital; the VTP map was limited. These protocols may not apply to other hospitals, which may require tailored approaches. The presented models should be validated at other institutions before they can be generalized. Secondly, this study was based on a field investigation, and considered facility characteristics including elevator size and corridor width; considering patient type alone may not be enough in this context. Thus, future studies should include more extensive pathway simulations. This study presented a method for designing and evaluating IHT protocols in out-patient areas. Investigators adapting this methodology should consider applicable facility characteristics and people flow, among other variables. The presented methodology helps reduce infection spread during the IHT of patients with an infectious disease.

Conclusions

This study has shown that IHT pathways for suspected COVID-19 patients should be planned rather than chosen at random. Moreover, time efficiency is not the only parameter that should be considered in an evacuation; human flow and access ways should be accounted for. Finally, using established pathways for IHT may help reduce the risk of infection spread.

Future studies should consider combining VTPs with cloud-based data to improve tracking and path recording. In addition, in the future, we intend to implement the presented protocol in a more complex setting to verify its applicability in improving patient safety.

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

YL contributed to the design of the study, participated in data collection and analysis, and participated in drafting this article. YG oversaw data collection, wrote the statistical analysis plan, conducted the analysis, and drafted and revised the article. PL, QZ, BY, and FC assisted in conducting the study and participated in data collection and analysis. YW assisted in conducting the study and participated in data collection.

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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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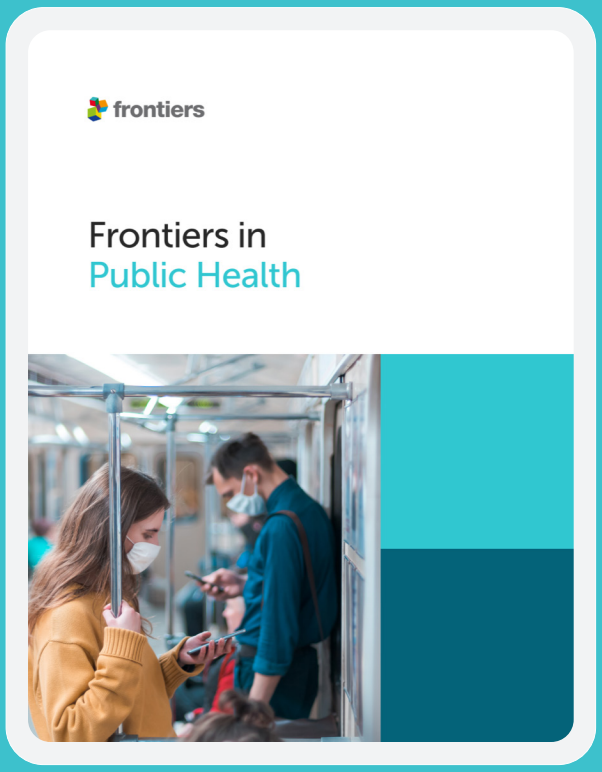

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