Received: 31 December 2020 | Revised: 2 February 2021 | Accepted: 3 February 2021

DOI: 10.1002/hpm.3137

REVIEW

WILEY

Health workforce surge capacity during the COVID-19 pandemic and other global respiratory disease outbreaks: A systematic review of health system requirements and responses

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Funding information
Government of Canada, Grant/Award Number: Canadian Research Continuity Emergency Fund

Abstract

Health system decision-makers need comprehensive evidence to mitigate surges in the demand for human resources for health (HRH) during infectious disease outbreaks. This study aimed to assess the state of the evidence on policy and planning responses to HRH surge capacity during the coronavirus disease (COVID-19) pandemic and other viral respiratory disease outbreaks of global significance in the 21st century. We systematically searched eight bibliographic databases to extract primary research articles published between January 2000 and June 2020 capturing temporal changes in health workforce requirements and responses surrounding respiratory virus pandemics. Following the Preferred Reporting Items for Systematic Reviews and Meta-analyses standard, 16 studies met our inclusion criteria. Five focused on COVID-19, three on H1N1, and eight modelled a hypothetical pandemic. Investigations of different training, mobilization, and redeployment options to address pandemic-time health system capacity were reviewed; however, few scenarios drew on observational HRH data,

and heterogeneity of study approaches and outcomes generally precluded comparability across contexts. Notable evidence gaps included occupational and psychosocial factors affecting healthcare workers' absenteeism and risk of burnout, gendered considerations of HRH capacity, evaluations in low- and lower-middle income countries, and policy-actionable assessments to inform post-pandemic recovery and sustainability of services for noncommunicable disease management.

KEYWORDS
COVID-19 pandemic, health workforce, supply of health personnel, surge capacity, systematic review

1 | INTRODUCTION

Health system decision-makers need comprehensive, policy-actionable evidence to mitigate not just the immediate risk of exposures to the respiratory pathogen causing the novel coronavirus disease (COVID-19) outbreak, but also longer-term impacts of pandemic responses. First detected in China's Hubei Province in late 2019, COVID-19 spread with unprecedented speed and was declared a global pandemic by the World Health Organization in March 2020.[1] The epidemiology of COVID-19 continues to increase demands on the health workforce while simultaneously diminishing healthcare worker supply due to occupational health hazards.[2] Outbreaks of respiratory viruses are widely associated with surges in the demand for human resources for health (HRH) to meet acute and critical care needs; such acute surge events may lead to decisions to divert resources from routine and specialist services.[3–5] The impact of such resource reallocations on health systems' abilities to manage chronic, noncommunicable diseases (NCDs) during the pandemic and post-pandemic periods are not well known. Adverse effects of pandemic mitigation strategies on NCD management in the longer term have received little stakeholder consensus or research attention.[6]

Healthcare expenditures are rising worldwide, and changes in demand for HRH are a substantial contributor to this trend.[7] Moreover, during outbreaks, healthcare workers may experience risk of infection, stress, anxiety and compassion fatigue, which may lead to increased absenteeism and burnout.[8–11] A study of the nursing workforce during the 2003 severe acute respiratory syndrome (SARS) outbreak in Toronto, Canada, found a just-in-time staffing policy for acute care increased overall healthcare costs, while lowering capacity in the community and long-term care sectors.[12] Effects of pandemic economic contractions will depend on policy responses; government policies to reduce budget deficits may be amplified for the largest spending sectors (including community health), resulting in health workers having potentially decreased job security, purchasing power, and labour market opportunities.[13] Substitution effects of relative price changes for HRH have been linked to subsequent reduced service supply.[14] Meanwhile, pandemic mitigation strategies may lead to increased future demand for primary care services at the population level; behavioural risk factors for unhealthy weight gain, substance misuse, and therapy nonadherence may have detrimental effects of NCD outcomes among children and adults due to school and business closures and other social distancing orders.[15,16]

This investigation systematically assessed the evidence on temporal changes in HRH supply and demand surrounding infectious respiratory disease outbreaks of global significance in the 21st century to help inform health system policies to manage surge capacity equitably and sustainably. Given the high consequences of surges, we used a systems approach, considering workers in hospitals, out-of-hospital systems, emergency medical services, and public health.[17] We focused on primary research of respiratory virus outbreaks identified

by the World Health Organization as having pandemic potential—such as SARS-CoV-2 (the virus causing COVID-19, previously referred to as 2019-nCoV), SARS, Middle East respiratory syndrome coronavirus (MERS-CoV), and novel influenza A (H1N1) virus.[1,18] The review aimed to address the following questions: (i) which policy-actionable factors affect the supply of and demand for healthcare workers during an acute respiratory illness pandemic; and (ii) to what extent do these same factors affect the supply of and demand for healthcare workers following a pandemic. Special consideration was paid to the unanticipated consequences of HRH surge capacity for sustaining primary care services, including for chronic physical and mental health conditions. Additionally, given the increasingly recognized importance of equity and leadership among women, who form the majority of the global health workforce,[2] we explicitly analysed the data through a gender lens.

2 | METHODS

2.1 | Study design

Our review followed a Population, Intervention, Comparison, Outcomes, Study type (PICOS) framework, in line with the Preferred Reporting Items for Systematic Reviews and Meta-analyses (PRISMA) guidelines.[19] We systematically searched, extracted, appraised, and synthesized the literature from multiple bibliographic databases for observational studies characterizing temporal changes in HRH capacity associated with pandemic-related increases in demand, without restriction for the health financing system. We included original studies published in peer-reviewed journals reporting primary quantitative research results addressing any of the following considerations: the impact of a viral respiratory illness outbreak on the supply of healthcare workers; the impact of a viral respiratory illness outbreak on the demand for healthcare workers; any health workforce policy or governance reactions to the outbreak; how any of these impacts or reactions were associated with any health workforce policies in response to the outbreak or post-pandemic recovery. Studies were included if they contained a comparator for changes over time either in the supply of healthcare workers before/during/after an outbreak, or in the demand for providers of healthcare services before/during/after an outbreak. Studies lacking at least two time point measures were excluded. Since only published works were included, and those were further restricted to studies tracking provider and/or patient populations over time, some risk of publication bias may have been raised; however, this approach was considered most appropriate for examining temporal relationships between exposures and outcomes (particularly salient in outbreak investigations) and for supporting quality control (as the available evidence in the earlier stages of disease outbreaks tends to be dominated by case reports and clinical series).[20,21] A description of our inclusion and exclusion criteria following the PICOS approach is found in Table 1. The study has been registered in the PROSPERO international database of systematic reviews in health and social care (registration number CRD42020178650).[22]

2.2 | Data sources

Eight electronic abstract and citation databases were searched: ABI/INFORM, CINAHL, Embase, EconLit, Medline, PsycINFO, Scopus, and SocINDEX. Peer-reviewed journal articles using quantitative observational data published between January 2000 and June 2020, in English and in French, were included. The search strategy included nomenclature related to HRH supply/demand dynamics (e.g., health human resources, healthcare capacity, surge capacity, physician redistribution, nurse reassignment), as well as nomenclature related to viral respiratory infection pandemics of global significance (e.g., virus outbreak, COVID-19, MERS, SARS, H1N1). Following an analysis of the titles, abstracts, and subject terms obtained from an exploratory search in one

TABLE 1 Inclusion and exclusion criteria for the systematic review of requirements and responses to address human resources for health (HRH) surge capacity

	Population, Intervention, Comparison, Outcomes, Study type (PICOS) elements				
Criteria	**Population**	**Intervention**	**Comparison**	**Outcome measures**	**Study design**
Included	Healthcare workers providing direct patient care: physicians, nursing and midwifery personnel, pharmacists, other allied-health workers	HRH governance responses related to viral respiratory infection pandemics of global significance in the 21st century (e.g., COVID-19, MERS, SARS, H1N1)	Changes over time in measures of HRH supply/demand surrounding pandemic periods	• HRH supply: Head counts, full-time equivalents, hours worked, service intensity • HRH demand: Healthcare needs, healthcare-seeking behaviours	Original quantitative observational studies: Cohort and multiple cross-sectional designs measuring pre-pandemic/pandemic or pandemic/post-pandemic outcomes
Excluded	Health administrators, researchers, and other non-frontline personnel	HRH governance responses to other pandemics (e.g., Ebola, AIDS), man-made or natural disasters, or other types of public health emergencies	Studies lacking at least 2 time point measures	• Health system capacity measures excluding HRH considerations	Process descriptions, commentaries, discussion papers, qualitative studies, conference abstracts, review articles

Abbreviations: MERS, Middle East respiratory syndrome; SARS, severe acute respiratory syndrome; AIDS, acquired immunodeficiency syndrome.

database, the search terms and filters were translated to respect each of the database-specific requirements. More details on the search strategy, including illustrative results of one database search, are available elsewhere in the review protocol.[22]

2.3 | Data extraction and analysis

Articles included in the review were limited to those having undergone a peer review process. The database searches were collated using the Rayyan reference management software,[23] from which de-duplication and eligibility screenings were conducted. The study setting, year(s) and type of outbreak, measures and coverage of the supply of healthcare workers, measures and coverage of the demand for healthcare workers, description of the HRH policy or governance reaction to manage surge capacity, and the study methodology used to assess impacts of the reaction were recorded. Two reviewers independently screened a sample of retrieved abstracts and, in turn, full-text articles, to identify and secure consensus on studies for review inclusion. Potential discrepancies were resolved through discussion with a third reviewer.

We performed a formal synthesis of the findings from the included studies using a PICOS-modelled table and narrative statements synthesizing whether there was an effect of a policy/governance change on the measured supply/demand for healthcare workers over time and, if so, which reactions were most effective in continuing to meet the demand in the post-pandemic period. Following research elsewhere, we evaluated the evidence for

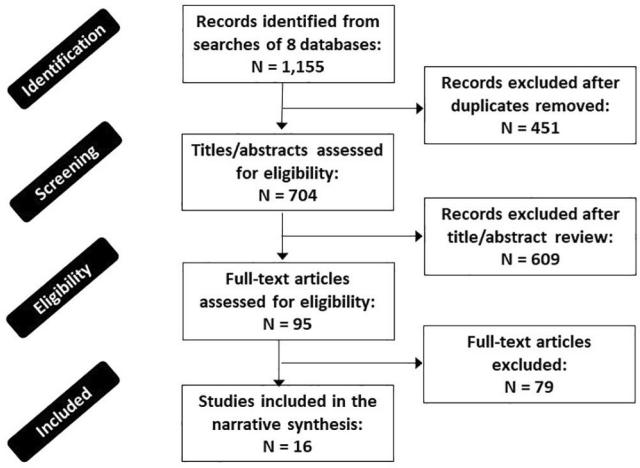

FIGURE 1 Flow chart for the selection of studies included in the systematic review of requirements and responses to address health workforce surge capacity

consideration of sex and gender in the HRH impact assessments.[24] Given the heterogeneity of outcome measures for provider practices and patient demand for healthcare services, it was not possible to conduct a meta-analysis.

3 | RESULTS

3.1 | Article retrieval and inclusion

A total of 1155 records were initially retrieved from the eight electronic databases. After the reconciliation of duplicate records (451) and application of the exclusion criteria (688), 16 full-text journal articles were retained for assessment. A PRISMA depiction of the flow of information is found in Figure 1.

3.2 | Characteristics of the studies

Following the PICOS framework, the characteristics of the 16 studies included in the narrative analysis are described in Table 2. The studies can be grouped into three categories: those focussing on a simulated influenza outbreak (eight articles, mostly published before 2011)[25–32]; those assessing temporal effects of the H1N1 pandemic (three articles published between 2011 and 2015)[33–35]; and those assessing effects at the early stages of the COVID-19 pandemic (five articles published in the first half of 2020).[36–40] Three-quarters (75%) of the retained articles covered high-income countries in Europe (five studies), North America (4), and Oceania (3); two (13%) studies covered upper-middle-income countries in South America; one (6%) covered a high-income economy in Asia; and one (6%) used a model population. Only five (31%) of the studies assessed the effects of a specific HRH intervention, notably, training and mobilization of healthcare workers to address pandemic-time health system capacity in a given context; most (63%) of the studies simply simulated increased demand for health workers with varying hypotheses surrounding supply factors, and one (6%) considered different staffing scenarios using inferential statistical modelling.

TABLE 2 Characteristics of the studies included in the systematic review of requirements and responses to address health workforce surge capacity

Author, year	Population, Intervention, Comparison, Outcomes, Study type (PICOS) elements				
	Population	Intervention	Comparison	Outcomes	Study design
Wilson et al. (2005)[25]	New Zealand; primary care physicians	Responsiveness in general practice	Simulated influenza outbreak	Primary care medical consultations	FluAid software package
Wilson et al. (2005)[26]	New Zealand; primary care physicians	Responsiveness in general practice	Simulated influenza outbreak	Lost workdays	FluAid software package (N = 3074 GPs)
Matthews et al. (2005)[27]	United States (state of Vermont); inactive/retired nurses, nursing faculty, and nursing students	Recruitment and training of clinical and community volunteers in emergency response	Simulated disease outbreak	General emergency preparedness knowledge; Likert scale measures of training evaluation	Pre- and post-response surveys
Ablah et al. (2007)[28]	United States (six counties in the state of Kansas); frontline public health and emergency workers	Training using electronic media to public health workers in local offices	Simulated disease outbreak	Likert scale measures of surge capacity, intercounty coordination, risk communication, and protocols and procedures	Pre- and post-response surveys (N = 47 postsurvey respondents)
Sokolow et al. (2018)[29]	United States (two locations in different states); community pharmacy workers	Training for pharmacy-based vaccine administration and medication dispensing	Simulated vaccine-preventable influenza outbreak	Patient flows at two time points	Training exercise data on patient movement and store configuration
Nap et al. (2007)[30]	Netherlands (three northern provinces); primary care physicians and intensive-care nurses	Regional and municipal health authorities' preparedness	Simulated influenza outbreak	GP consultations; ICU bed occupancy; healthcare worker absenteeism	FluSurge software package and computational model
Nap et al. (2008)[31]	Netherlands (northern region); intensive-care nurses	Regional and municipal health authorities' preparedness	Simulated influenza outbreak	Nursing workload and ICU bed occupancy	FluSurge software package and computational model
Nap et al. (2010)[32]	Netherlands (northern region); paediatric healthcare workers	Regional and municipal health authorities' preparedness	Simulated influenza outbreak	GP consultations; paediatric ICU bed occupancy	FluSurge software package and computational model
Meites et al. (2011)[33]	Argentina (Buenos Aires); reference hospital workers	Hospital preparedness	2008 influenza season versus 2009 H1N1 pandemic influenza	Bed-days occupied for respiratory critical care	Administrative hospital records; interviews with hospital leadership

(Continues)

TABLE 2 (Continued)

Author, year	Population, Intervention, Comparison, Outcomes, Study type (PICOS) elements				
	Population	Intervention	Comparison	Outcomes	Study design
Simonsen et al. (2013)[34]	Norway; primary care physicians	Responsiveness in general practice (day-time services) versus out-of-hours services	2008/09 influenza season versus 2009 A (H1N1) pdm09 pandemic influenza	GP consultations	Registry of physician services (*N*≈4100 GPs)
Ip et al. (2015)[35]	Hong Kong; workers in public hospitals and outpatient clinics	Health authority preparedness	2004–2008 influenza seasons versus 2009 A (H1N1) pdm09 pandemic influenza	Sickness absenteeism among healthcare workers	Registry of sickness absence certificates (*N*≈60,000 medical, nursing, allied, management, and support staff)
Verelst et al. (2020)[36]	Europe (27 European Union countries); physicians and nurses	Healthcare system preparedness	Baseline versus 2020 SARS-CoV-2 pandemic	Composite measures of healthcare workers and critical care beds	Official statistical sources on healthcare resources
Lima et al. (2020)[37]	Brazil (São Paulo); reference hospital orthopaedic workers	Training to care for flu-like syndromes; reorganization of working shifts	Two-week periods before and after response intervention to 2020 SARS-CoV-2 pandemic	Orthopaedists trained; shifts reorganized; classes and tests suspended/carried out	Administrative hospital records (*N*≈250 orthopaedic team members)
Philipps et al. (2020)[38]	United States (New York City); reference hospital paediatric physicians and nurses	Training by adult-trained medicine providers for surge-in-place	Before and after opening of a paediatric hospital unit to adults for management of COVID-19	Clinical outcomes of adult patients	Administrative hospital records (*N* = 100 adult patients)
Gardiner et al. (2020)[39]	Australia; air transport medical service workers	Ambulance system preparedness in rural and remote areas	2015–2019 baseline versus 2020 simulated outbreak of respiratory illnesses including COVID-19	Aircraft capacity; time to mobilization	Computational model using administrative data on air medical retrievals
Mascha et al. (2020)[40]	Model population; model hospital-based staff of physicians, nurses, and respiratory therapists	Scenarios of routine versus pandemic-time staffing models	Model baseline versus 2020 in-hospital COVID-19 infection probabilities	Weekly clinical staff coverage for ICU services	Statistical model

Abbreviations: GP, general practitioner; ICU, intensive care unit.

3.3 | Factors considered to affect HRH surge capacity during simulated influenza pandemics

The simulation studies included in the review generally recognized the need to address changes in the supply of healthcare workers during outbreak events, using different approaches and analytical complexity, and covering distinct geopolitical levels in which health systems operate. In two studies which considered a simulated influenza pandemic in New Zealand, Wilson and colleagues modelled scenarios for addressing surge capacity for primary care consultations among general practitioners (GPs).[25,26] One scenario hypothesized that, at the outbreak's peak, only 50% to 75% of practising GPs would be working, given predicted absences due to illness or caring for relatives, resulting in significant increases in average weekly caseloads among working GPs.[25] It was hypothesized elsewhere that working physicians would be less likely to experience severe sequelae from influenza infection than the general population, given lower smoking rates and other risk factors for chronic respiratory disease (referred to as the 'healthy worker effect'), resulting in fewer working days lost compared with the patient population with high-risk conditions.[26] The authors suggested broad strategies to manage increased demand for GP services, including shifting consultations to registered nurses working in primary care, and reducing numbers of administrative-type consultations by relaxing employer requirements for medical certificates associated with influenza-like illness.

In-service and post-service training and mobilization were the focus of three HRH intervention studies covering different cadres and settings in the United States. Recognizing the lack of sufficient numbers of highly specialized healthcare workers to meet surges in acute care needs in largely rural communities, two studies in the states of Vermont and Kansas implemented pre- and post-intervention surveys to assess the impacts of pilot training programs to build local capacity for emergency preparedness.[27,28] Pre-service nursing students and post-service retired nurses were the main target audience for emergency response clinical training in one setting.[27] In-service public health workers, mostly nurses and administrative assistants, were trained using electronic tools to identify the need for and implement surge capacity in another setting.[28] Although the short-term trainings both generally yielded improved levels of emergency preparedness knowledge, identified constraints included the sustainability of volunteers' interest and skill level as well as travel times and other logistics to conduct training sessions.

Also in the United States, Sokolow and colleagues reported on the results of pandemic response exercises to enhance efficiency of patient flows conducted among community-based pharmacy workers in two locations.[29] For second runs of the exercises, numbers of pharmacist, technician, and nontechnical staff were increased to augment capacity for vaccine administration and medication dispensing. Challenges in determining the optimal number of staff needed to optimize patient throughput were identified since, in this context, pharmacies offered multiple services and staff often multitasked.

In three studies based on a simulated influenza pandemic in the Netherlands, Nap and colleagues considered health system responsiveness for surges in GP consultations as well as nursing workload and occupancy of hospital beds in intensive care units (ICUs) in the country's northern region.[30–32] Predicted absenteeism was incorporated under the assumption that healthcare workers would become ill at a similar rate as the general patient population.[30,31] The authors explicitly assumed in the presented models a lack of absenteeism due to the need to care for sick family members or fear of illness. Surge capacity among ICU nurses was considered to be addressed through expansion of working shifts from 8 to 12 h (expecting that nursing staff would all 'comply') and shifting of nontechnical duties to non-ICU nurses, administrative staff, and other hospital personnel under the prediction of decreases in non–influenza-related patients.[30] Albeit recognizing ethical impacts on clinical workers surrounding end-of-life decisions, the authors did not incorporate measures of worker burnout in the staffing models.[30] When looking specifically at an influenza pandemic for children, paediatric surge capacity was considered to be manageable through the rerouting of 'older children' (aged 7–8 years and above) to an adult ICU environment; the authors acknowledged this response could entail 'immense pressure' on clinical workers accustomed to caring for adults.[32]

3.4 | Factors considered to affect HRH surge capacity during the H1N1 pandemic

Three studies included in the review drew on administrative health datasets to assess temporal changes in health system outcomes in the H1N1 pandemic period compared with previous influenza seasons. In Argentina's largest national hospital, pandemic planning was considered crucial to meeting adult critical care needs during peak days of the outbreak.[33] Workforce planning involved the need to accommodate a national policy to furlough workers with high-risk medical conditions; in the study setting, data revealed that 6% of hospital nurses accepted six weeks of paid leave over three months.[33] While overall nursing absences were found to be similar to pre-pandemic periods, unscheduled absences increased, reaching a peak of 43% of nurses scheduled for duty on a given day. Nursing surge capacity was managed through temporary hiring, cancellation of vacations and other scheduled absences, and shifting to higher acuity care areas (given fewer hospitalized patients attributable to postponed surgeries). The authors noted that a 43% nursing staff absenteeism rate during the pandemic was not unusually high, as baseline rates up to 46% had been observed before the pandemic in other South American hospitals.[33]

In Norway, physician registry data were analysed to enhance understanding of pressures from the H1N1 pandemic on the delivery of primary care medical services.[34] Simonsen and colleagues reported that the majority of medical consultations for influenza-like illness took place in day-time general practices (characterized by mostly pre-booked appointments with limited availability for acute illnesses every day). Out-of-hours services (those organized with an empty schedule at the start of each shift) experienced a 5.5-fold increase in consultations compared with the previous season as baseline; however, total physician out-of-hours capacity remained stable against the pre-pandemic period due to decreases in non-influenza consultations.[34]

A study in Hong Kong assessed registry-based data on sickness absences during the H1N1 pandemic among medical, nursing, allied-health, management, and support staff in hospitals and outpatient clinics.[35] The pandemic period was found to be marked with 58% excess in sickness absenteeism, compared with 8% excess during previous influenza seasons.[35] The excess in absenteeism was highest in the peak of the pandemic among medical staff (15-fold higher), although nursing staff had higher absence levels during non-epidemic periods. The authors noted that HRH productivity losses during a pandemic come not only from sickness absences but also other reasons such as family care responsibilities for children during school closures, for which data were lacking.

3.5 | Factors considered to affect HRH surge capacity during the COVID-19 pandemic

Five journal articles published in the first half of 2020 were retained for narrative analysis focussing on health system requirements and responses to COVID-19 as the pandemic was unfolding. Verelst and colleagues summarized their analyses of healthcare system capacity to address the magnitude and intensity of the pandemic drawing on national official statistics on healthcare workers, hospital beds, and healthcare expenditure across European Union countries.[36] Much of the multi-country data on base capacity dated from 2018 or earlier; some of the data on critical care beds were from 2010. At the time of the study, the composite measures of healthcare capacity pointed to Italy, Spain, the Netherlands, and France as experiencing the highest pressures from COVID-19 deaths and active cases. The authors noted a lack of accounting for countries' potential HRH capacity expansion in response to the pandemic (e.g., mobilising volunteers or retired healthcare workers) or for healthcare workers' incapacitation from the disease.[36]

In a study of an urban reference hospital in Brazil, administrative data were used to track adaptation of work including changes in academic and scientific activities among orthopaedic personnel surrounding the rapid implementation of intervention protocols to address the COVID-19 outbreak.[37] Given short-term reduced demand for surgeries, orthopaedists were trained in the care and management of patients with low-complexity flu

syndromes while numbers of clinical-scientific meetings were decreased. The authors contended that the study demonstrated the feasibility of rapid implementation of intervention protocols across hospital departments to meet pandemic-related needs.

Claiming there is limited literature on how children's hospitals should respond when adults are most affected by disease morbidity and mortality during an outbreak, Philips and colleagues reported on the rapid implementation of a children's hospital-based 'surge-in-place' adult COVID-19 unit in New York City.[38] The surge-in-place approached relied primarily on paediatric physicians and nurses, whose previous trainings and work adaptations to COVID-19 mitigation policies and practices were rapidly expanded to include care for adults with COVID-19, with the support of adult-trained hospital medicine consultants. The authors argued that familiarity with their own hospital system and team members enhanced healthcare workers' adaptability to care for new patient populations, thus favouring this approach over establishing temporary hospitals. It was noted that the paediatric health workers may have been less familiar with the treatment and management of common adult medical conditions; however, in this setting, patients were not admitted randomly to the paediatric unit and generally had fewer comorbidities including diabetes and other NCDs.[38]

In a context characterized with more rural and remote areas, preparing for surges requiring air services for interhospital transfers, primary evacuations, and repatriations was the focus of a study by Gardiner and colleagues in Australia.[39] Using administrative data on air medical retrievals, the authors reported that meeting increased demand from COVID-19 and its potential trajectory was more dependent on the workforce available to staff and provide maintenance on aircraft (i.e., clinical staff, pilots, and engineers), rather than on the number of aircraft which was assessed as unlikely to be a major challenge. While volunteer pilots offset some of the increased demand for services, shortages of clinical staff and engineers remained significant barriers.[39]

Lastly, Mascha and colleagues modelled COVID-19 infection probabilities to assess potential hospital-based staffing shortages related to infections, quarantine times, and deaths among physicians, nurses, and respiratory therapists in a hypothetical ICU setting.[40] The authors constructed various staffing models and simulated different probabilities of in-hospital staff infections with COVID-19 over time using statistical distributions of random likelihood. Results showed a consistent dip in worker availability after four weeks of a COVID-19 outbreak, and led to authors to recommend pandemic-adjusted staff scheduling to minimize disruptions to ICU operations as well as prioritization of protection and surveillance of employee health. The authors acknowledged that their optimal pandemic scenario entailed a net increase in working time to mitigate shortages of the affected workforce.[40]

3.6 | Sex and gender considerations in the published research

Of the 16 studies retained for narrative review, three (19%) considered the sex of patients in the pandemic impact analysis. In the United States, Philips and colleagues counted newly admitted adult patients with COVID-19 by sex in a large urban hospital setting; 69% of the inpatients were male, a descriptive considered in line with epidemiological patterns emerging from China.[38] Gardiner and colleagues used sex-disaggregated data to characterize air medically retrieved patients with confirmed or suspected COVID-19 in Australia; more patients were found to be male than female but 11% of cases were missing information on sex in the administrative data.[39] Simonsen and colleagues distinguished male and female patients with influenza-like illness before and during a pandemic in Norway, and found no significant differences in primary care medical consultations.[34]

None (0%) of the retained studies included any description of sex-specific provider characteristics or gave substantive notice to gender as relevant to assessing HRH surge capacity. One study reported on adaptation of surge environments to minimize risk of adverse impacts on adults' chronic illness comorbidities,[38] but none discussed potential adaptations to maintain appropriate sexual and reproductive health services.

4 | DISCUSSION

Health system capacity strain during respiratory viral disease outbreaks may be considered in terms of preparedness for hospital space (beds), personnel (clinical and nonclinical staff), physical equipment (e.g., mechanical ventilators, personal protective equipment), and governance (planning and coordination).[3] Much attention during the COVID-19 outbreak has centred on hospital ICU bed availability and occupancy; however, infectious disease surges present system-wide challenges including for public health, primary and community care, and ambulance services. It is increasingly recognized that issues of availability, leadership, training, movement, and health and wellbeing of healthcare workers are critically important for coordinated response efforts; yet, many response plans inadequately explicitly address HRH requirements and considerations.[2,3,16,41] We systematically reviewed the research evidence on policy options to enhance HRH surge capacity and sustain post-pandemic workforce deployment and management. The results revealed a wide range of topics addressing HRH supply/demand dynamics even with a relatively small sample of studies ($N = 16$), a finding similar to reviews elsewhere of the early literature to address the COVID-19 pandemic.[42] The results further underscored the scarcity of data-driven evaluations of the impact of HRH governance inventions designed to address surge capacity. Many of the narratively reviewed studies focussing on HRH productivity changes during a pandemic came from hypothetical scenario-based assessments in different hospital and community settings.

Fewer than one-third of the reviewed studies assessed the effects of a specific HRH intervention, and those that did largely focused on short-term emergency response training and mobilization goals. Among the recommended policy actions included the development of protocols to inform reallocation of resources and task shifting,[37,39] pandemic-adjusted staffing models,[30,32,40] expanded training for in-service workers,[27–29,37,38] and engagement of a variety of types of volunteers as a standby pool.[27,39] Such activities were argued to facilitate the rapid implementation of HRH supply enablers to address surge capacity, although the findings from any given study context tended to be of unclear generalizability to different countries and settings. As such, the ongoing need for flexibility and adaptability remained a key concern given the unpredictability of the duration or course of viral pandemics. A number of HRH plans and models considered evolving patterns of staff absenteeism[26,30,33,35,40]; the research was mixed in terms of the direction related to specific reasons for absence (e.g., high-risk vs. low-risk of complications, fear of illness vs. moral obligation to continue working during viral outbreaks).

None of the studies focused on HRH issues in post-pandemic periods; as such, we were unable to answer our second research question as to which governance options were most amenable to pandemic recovery, such as addressing mental health impacts on healthcare workers or backlogs of nonurgent surgeries and service needs for NCD management. In non-pandemic situations, reallocation of resources away from specific clinical services has been found to entail negative responses among healthcare staff due to perceived threats to their professional identity.[43] Research is needed to inform HRH governance decisions to address potentially unintended consequences of health workers' reactions of perceived disempowerment during resource reallocations in response to acute surge events.

Disconcertingly, none of the retained studies measured occupational or psychosocial factors affecting healthcare workers' morbidity levels or risk of burnout. In the absence of real data, some researchers assumed healthcare staff would be less likely to experience severe morbidity from acute respiratory syndromes due to the healthy worker effect, while others assumed that healthcare personnel would become ill at a similar rate as the general population. Some limited research from the first wave of the pandemic found the risk of hospitalization with COVID-19 was higher among healthcare workers and members of their families than the general working age population.[44] Clarifying the prevalence of high-risk health conditions among the health workforce would be a particularly important refinement in the evidence base; another would be improving the estimates

of work absenteeism for non-medical reasons, such as from fear of infection or transmission to family, stresses of seeing colleagues falling sick, the need to care for relatives, and the need for physical and psychological self-care.[26,40,45] The ethics of simply compelling health workers to provide care during a pandemic through moral or legal obligations are increasingly questioned; rather, more observational research is needed to investigate impacts and remediate likely causes for absenteeism.[46–49]

The present evidence gap on health worker absenteeism for reasons of child and elder care responsibilities may be related to the lack of attention to sex and gender considerations in the published research. This finding was not entirely surprising, echoing a systematic review elsewhere demonstrating a dearth of research on sex-specific HRH outcomes to help inform gender-equitable health workforce policy options.[24] Although the latest epidemiological data indicates that COVID-19 may pose higher morbidity and mortality risks to men, a growing body of evidence suggests that public health emergencies disproportionately affect women.[50] Women comprise of 70% of the health and social care workforce in many countries.[51] Women may be more likely than men to experience disruptions in their daily routines and labour market activities as frontline healthcare workers during pandemic periods due in part to gendered socialization for caregiving, which may be exacerbated with prolonged school closures and shifts to online learning.[35,50,52] However, sex-disaggregated data related to disease outbreaks have often been found to be incomplete,[52] a discrepancy also observed in our reviewed data.[39] Gender-blindness remains persistent in research and governance of public health emergencies.[53]

4.1 | Study strengths and limitations

The overall quality of the literature included in this review was generally considered to be high, given the research protocol restricting eligibility to refereed journal articles designed to explore temporal effects on health system capacity, notably using routinely collected health data or repeated measures designs. Many of the records initially retrieved in the bibliographic searches were cross-sectional studies, which cannot often be used to determine temporal relationships and thus did not meet our prospectively planned eligibility criteria. While few studies were ultimately included for narrative analysis, and much of the available research was conducted before the full impact of the COVID-19 pandemic can be known, these constraints are consistent with reviews elsewhere of HRH outcomes associated with infectious disease outbreaks.[8] It is noted that, in the COVID-19 era, there has been a proliferation of academic and grey literature, often reporting on investigations undertaken rapidly and using non-randomly collected data; the quality of the available evidence in situations involving coronavirus outbreaks has been widely found to be inconsistent.[21,42,54]

An important limitation of the present results was the lack of a universal definition of 'surge capacity'. Oftentimes, addressing HRH surge capacity was equated in the reviewed literature with increasing the numbers of active providers or their hours worked. However, analyses of health labour market dynamics describe a range of HRH planning criteria including needs-based, demand-based, supplier-induced demand, utilization-based, or supply-based approaches, which are not interchangeable constructs.[7,55,56] Moreover, health workforce shortages to meet global health goals were widely quantified before the COVID-19 crisis; while the stock of healthcare workers is generally expected to grow in the coming years, it is unclear whether the numbers, practice patterns, geographic distributions, and skills mixes will meet the future needs of populations with changing demographics, disease patterns, service delivery capacities, and fiscal spaces.[55–57] Health workforce shortages are especially severe in low and lower-middle income countries; the requirements and capacity for many African countries for pandemic response and post-pandemic recovery are largely unknown.[6,16] The absence in this review of data from such contexts reflects major shortcomings in the global health research capacity.

5 | CONCLUSIONS

This study represents, to our knowledge, the first systematic appraisal of the state of the research evidence on HRH surge capacity during COVID-19 and other respiratory virus outbreaks of global significance using a health systems approach. Monitoring and analysing the impacts of COVID-19 is crucial to help inform strategic actions to ensure maintenance of access to essential health services throughout the course of the outbreak, and to mitigate threats to health workforce sustainability. Adaptable strategies are vital in acute surge events,[3] and the current pandemic offers a stark reminder of the need to invest in HRH data and research. At the time of writing, new COVID-19 vaccines were being rolled out in a number of countries; the World Health Organization recognized that, while disruptions of essential health services were continuing and many challenges would undoubtedly persist, a path to moving beyond emergency response was finally emerging.[1] Consolidated guidance for strengthening national and subnational HRH information systems had been released, including for supporting and protecting healthcare workers through enhanced tracking of demographics, exposures, infections, quarantines, and deaths.[58] Findings from this assessment emphasize the critical need for more timely, comprehensive, internationally comparable, and equity-informative HRH evidence to enhance preparedness, response, and recovery policies for this and future pandemics.

ACKNOWLEDGEMENTS

Selected findings from this research were presented at the Canadian Health Workforce Network 2020 Virtual Conference (9–10 December 2020). Financial support for this work was received from the Canadian Research Continuity Emergency Fund.

CONFLICT OF INTEREST

The authors declare they have no competing interests.

DATA AVAILABILITY STATEMENT

Not applicable. No datasets were generated or analyzed.

ETHICS STATEMENT

Not applicable as no human subject participants were involved.

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REFERENCES

1. World Health Organization. *Coronavirus disease (COVID-19) pandemic*. Accessed January 25, 2021. https://www.who.int/emergencies/diseases/novel-coronavirus-2019.
2. Bourgeault IL, Maier CB, Dieleman M, et al. The COVID-19 pandemic presents an opportunity to develop more sustainable health workforces. *Hum Resour Health*. 2020;18(83):1-8. https://doi.org/10.1186/s12960-020-00529-0.
3. Anesi GL, Lynch Y, Evans L. A conceptual and adaptable approach to hospital preparedness for acute surge events due to emerging infectious diseases. *Crit Care Explor*. 2020;2(4):e0110. https://doi.org/10.1097/CCE.0000000000000110.
4. Seda G, Parrish JS. Augmenting critical care capacity in a disaster. *Crit Care Clin*. 2019;35(4):563-573. https://doi.org/10.1016/j.ccc.2019.06.007.
5. Ammar A, Stock AD, Holland R, Gelfand Y, Altschul D. Managing a specialty service during the COVID-19 crisis: lessons from a New York City health system. *Acad Med*. 2020;95(10):1495-1498. https://doi.org/10.1097/ACM.0000000000003440.
6. Correia T SARS-CoV-2 pandemics: the lack of critical reflection addressing short- and long-term challenges. *Int J Health Plann Manag*. 2020;35(3):669-672. https://doi.org/10.1002/hpm.2977.

7. Léonard C, Stordeur S, Roberfroid D. Association between physician density and health care consumption: a systematic review of the evidence. *Health Pol*. 2009;91(2):121-134. https://doi.org/10.1016/j.healthpol.2008.11.013.
8. Brooks SK, Dunn R, Amlôt R, Rubin GJ, Greenberg N. A systematic, thematic review of social and occupational factors associated with psychological outcomes in healthcare employees during an infectious disease outbreak. *J Occup Environ Med*. 2018;60(3):248-257. https://doi.org/10.1097/JOM.0000000000001235.
9. Cocker F, Joss N. Compassion fatigue among healthcare, emergency and community service workers: a systematic review. *Int J Environ Res Publ Health*. 2016;13(618):1-18. https://doi.org/10.3390/ijerph13060618.
10. Lai J, Ma S, Wang Y, et al. Factors associated with mental health outcomes among health care workers exposed to coronavirus disease 2019. *JAMA Netw Open*. 2020;3(3):e203976. https://doi.org/10.1001/jamanetworkopen.2020.3976.
11. Tan BYQ, Kanneganti A, Lim LJH, et al. Burnout and associated factors among health care workers in Singapore during the COVID-19 pandemic. *J Am Med Dir Assoc*. 2020;21(12):1751-1758.e5. https://doi.org/10.1016/j.jamda.2020.09.035.
12. Baumann AO, Blythe JM, Underwood JM. Surge capacity and casualization: human resource issues in the post-SARS health system. *Can J Public Health*. 2006;97(3):230-232. https://doi.org/10.1007/BF03405592.
13. Jesus TS, Kondilis E, Filippon J, Russo G. Impact of economic recessions on healthcare workers and their crises' responses: study protocol for a systematic review of the qualitative and quantitative evidence for the development of an evidence-based conceptual framework. *BMJ Open*. 2019;9(11):e032972. https://doi.org/10.1136/bmjopen-2019-032972.
14. Shearer B, Somé NH, Fortin B. *Measuring Physicians' Response to Incentives: Evidence on Hours Worked and Multitasking*. Centre de recherche sur les risques les enjeux économiques et les politiques publiques; 2018:52. http://dx.doi.org/10.2139/ssrn.3211451.
15. Rundle AG, Park Y, Herbstman JB, Kinsey EW, Wang YC. COVID-19–related school closings and risk of weight gain among children. *Obesity*. 2020;28(6):1008-1009. https://doi.org/10.1002/oby.22813.
16. Okereke M, Ukor NA, Adebisi YA, et al. Impact of COVID-19 on access to healthcare in low- and middle-income countries: current evidence and future recommendations. *Int J Health Plann Manag*. 2021;36(1):13-17. https://doi.org/10.1002/hpm.3067.
17. Schultz CH, Koenig KL. State of research in high-consequence hospital surge capacity. *Acad Emerg Med*. 2006;13(11):1153-1156. https://doi.org/10.1197/j.aem.2006.06.033.
18. World Health Organization. *Managing Epidemics: Key Facts about Major Deadly Diseases*. World Health Organization; 2018.
19. Liberati A, Altman DG, Tetzlaff J, et al. The PRISMA statement for reporting systematic reviews and meta-analyses of studies that evaluate health care interventions: explanation and elaboration. *PLoS Med*. 2009;6(7):e1000100. https://doi.org/10.1371/journal.pmed.1000100.
20. Dekkers OM, Vandenbroucke JP, Cevallos M, Renehan AG, Altman DG, Egger M. COSMOS-E: guidance on conducting systematic reviews and meta-analyses of observational studies of etiology. *PLoS Med*. 2019;16(2):1-24. https://doi.org/10.1371/journal.pmed.1002742.
21. Yu Y, Shi Q, Zheng P, et al. Assessment of the quality of systematic reviews on COVID-19: a comparative study of previous coronavirus outbreaks. *J Med Virol*. 2020;92(7):883-890. https://doi.org/10.1002/jmv.25901.
22. Gupta N, Balcom SA, Witherspoon RL. *Health System Responses to Changes in the Supply and Demand for Healthcare Workers during and after a Viral Respiratory Infection Pandemic: Protocol for a Systematic Review of the Evidence to Inform Post-Pandemic Preparedness*. University of New Brunswick; 2020:12. https://unbscholar.lib.unb.ca/islandora/object/unbscholar%3A10292.
23. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan—a web and mobile app for systematic reviews. *Syst Rev*. 2016;5(210):1-10. https://doi.org/10.1186/s13643-016-0384-4.
24. Gupta N, Ayles HM. The evidence gap on gendered impacts of performance-based financing among family physicians for chronic disease care: a systematic review reanalysis in contexts of single-payer universal coverage. *Hum Resour Health*. 2020;18(69):1-15. https://doi.org/10.1186/s12960-020-00512-9.
25. Wilson N, Mansoor O, Baker M. Estimating the impact of the next influenza pandemic on population health and health sector capacity in New Zealand. *N. Z Med J*. 2005;118(1211):1-10.
26. Wilson N, Baker M, Crampton P, Mansoor O. The potential impact of the next influenza pandemic on a national primary care medical workforce. *Hum Resour Health*. 2005;3(7):1-6. https://doi.org/10.1186/1478-4491-3-7.
27. Matthews AK, Sprague K, Girling E, Dapice L, Palumbo MV, Berry P. Emergency preparedness volunteer training program. *J Publ Health Manag Pract*. 2005;11(Supplement):S63-S67. https://doi.org/10.1097/00124784-200511001-00011.
28. Ablah E, Nickels D, Hodle A, et al. "Public Health Investigation": a pilot, multi-county, electronic infectious disease exercise. *Am J Infect Contr*. 2007;35(6):382-386. https://doi.org/10.1016/j.ajic.2006.08.007.

29. Sokolow LZ, Patel A, Koonin LM, Graitcer SB. Scripted surge pharmacy pandemic exercise: testing vaccine administration and antiviral dispensing. *Health Secur*. 2018;16(4):262-273. https://doi.org/10.1089/hs.2018.0031.
30. Nap RE, Andriessen MPHM, Meessen NEL, van der Werf TS. Pandemic influenza and hospital resources. *Emerg Infect Dis*. 2007;13(11):1714-1719. https://doi.org/10.3201/eid1311.070103.
31. Nap RE, Andriessen MPHM, Meessen NEL, Miranda DR, van der Werf TS. Pandemic influenza and excess intensive-care workload. *Emerg Infect Dis*. 2008;14(10):1518-1525. https://doi.org/10.3201/eid1410.080440.
32. Nap RE, Andriessen MPHM, Meessen NEL, Albers MJIJ, van der Werf TS. Pandemic influenza and pediatric intensive care. *Pediatr Crit Care Med*. 2010;11(2):185-198. https://doi.org/10.1097/PCC.0b013e3181cbdd76.
33. Meites E, Farias D, Raffo L, et al. Hospital capacity during an influenza pandemic—Buenos Aires, Argentina, 2009. *Infect Control Hosp Epidemiol*. 2011;32(1):87-90. https://doi.org/10.1086/657667.
34. Simonsen KA, Hunskaar S, Sandvik H, Rortveit G. Capacity and adaptations of general practice during an Influenza pandemic. *PLoS One*. 2013;8(7):e69408. https://doi.org/10.1371/journal.pone.0069408.
35. Ip DKM, Lau EHY, Tam YH, So HC, Cowling BJ, Kwok HKH. Increases in absenteeism among health care workers in Hong Kong during influenza epidemics, 2004–2009. *BMC Infect Dis*. 2015;15(586):1-9. https://doi.org/10.1186/s12879-015-1316-y.
36. Verelst F, Kuylen E, Beutels P. Indications for healthcare surge capacity in European countries facing an exponential increase in coronavirus disease (COVID-19) cases, March 2020. *Euro Surveill*. 2020;25(13):1-4. https://doi.org/10.2807/1560-7917.ES.2020.25.13.2000323.
37. Lima EBS, Belangero PS, Falótico GG, Mansur NSB, Luzo MVM, Reis FB. Intervention protocol of the Orthopedics and Traumatology Department of a high-complexity university hospital to cope with the COVID-19 pandemic. *Rev Bras Ortop*. 2020;55(3):269-277. https://doi.org/10.1055/s-0040-1712972.
38. Philips K, Uong A, Buckenmyer T, et al. Rapid implementation of an adult coronavirus disease 2019 unit in a children's hospital. *J Pediatr*. 2020;222:22-27. https://doi.org/10.1016/j.jpeds.2020.04.060.
39. Gardiner FW, Johns H, Bishop L, Churilov L. Royal Flying Doctor Service coronavirus disease 2019 activity and surge modeling in Australia. *Air Med J*. 2020;39(5):404-409. https://doi.org/10.1016/j.amj.2020.05.011.
40. Mascha EJ, Schober P, Schefold JC, Stueber F, Luedi MM. Staffing with disease-based epidemiologic indices may reduce shortage of intensive care unit staff during the COVID-19 pandemic. *Anesth Analg*. 2020;131(1):24-30. https://doi.org/10.1213/ANE.0000000000004849.
41. Salas-Vallina A, Ferrer-Franco A, Herrera J. Fostering the healthcare workforce during the COVID-19 pandemic: shared leadership, social capital, and contagion among health professionals. *Int J Health Plann Manag*. 2020;35(6):1606-1610. https://doi.org/10.1002/hpm.3035.
42. Douthit BJ. The influence of the learning health system to address the COVID-19 pandemic: an examination of early literature. *Int J Health Plann Manag*. Published online 2020:1-8. https://doi.org/10.1002/hpm.3088.
43. Mitchell D, Bowles K-A, O'Brien L, Bardoel A, Haines T. Health care staff responses to disinvestment—a systematic search and qualitative thematic synthesis. *Health Care Manag Rev*. 2021;46(1):44-54. https://doi.org/10.1097/HMR.0000000000000239
44. Shah ASV, Wood R, Gribben C, et al. Risk of hospital admission with coronavirus disease 2019 in healthcare workers and their households: nationwide linkage cohort study. *BMJ*. 2020;371(m3582):1-11. https://doi.org/10.1136/bmj.m3582.
45. Lai TST, Yu WC. The lessons of SARS in Hong Kong. *Clin Med*. 2010;10(1):50-53. https://doi.org/10.7861/clinmedicine.10-1-50.
46. Powell T Carrots and sticks: keeping healthcare workers on the job in a public health disaster. *Am J Bioeth*. 2008;8(8):20-21. https://doi.org/10.1080/15265160802318154.
47. Iserson K. Healthcare ethics during a pandemic. *West J Emerg Med*. 2020;21(3):477-483. https://doi.org/10.5811/westjem.2020.4.47549.
48. Bartlett JG. Planning for avian influenza. *Ann Intern Med*. 2006;145(2):141-144. https://doi.org/10.7326/0003-4819-145-2-200607180-00133.
49. Kipnis K, Shander A. The taxonomy of calamity: the view from the operating room. *Int Anesthesiol Clin*. 2015;53(3):79-89. https://doi.org/10.1097/AIA.0000000000000069.
50. Fuhrman S, Kalyanpur A, Friedman S, Tran NT. Gendered implications of the COVID-19 pandemic for policies and programmes in humanitarian settings. *BMJ Glob Health*. 2020;5(e002624):1-5. https://doi.org/10.1136/bmjgh-2020-002624.
51. Boniol M, McIsaac M, Xu L, Wuliji T, Diallo K, Campbell J. *Gender Equity in the Health Workforce: Analysis of 104 Countries*. World Health Organization; 2019:8.
52. Wenham C, Smith J, Morgan R. COVID-19: the gendered impacts of the outbreak. *Lancet*. 2020;395(10227):846-848. https://doi.org/10.1016/S0140-6736(20)30526-2.

53. Davies SE, Bennett B. A gendered human rights analysis of Ebola and Zika: locating gender in global health emergencies. *Int Aff*. 2016;92(5):1041-1060. https://doi.org/10.1111/1468-2346.12704.
54. Yates T, Zaccardi F, Razieh C, et al. Framework to aid analysis and interpretation of ongoing COVID-19 research. *Wellcome Open Res*. 2020;5(208):1-7. https://doi.org/10.12688/wellcomeopenres.16227.1.
55. Tomblin Murphy G, Birch S, MacKenzie A, Bradish S, Elliott Rose A. A synthesis of recent analyses of human resources for health requirements and labour market dynamics in high-income OECD countries. *Hum Resour Health*. 2016; 14(59):1-16. https://doi.org/10.1186/s12960-016-0155-2.
56. Scheffler RM, Campbell J, Cometto G, et al. Forecasting imbalances in the global health labor market and devising policy responses. *Hum Resour Health*. 2018;16(5):1-10. https://doi.org/10.1186/s12960-017-0264-6.
57. Bates I, John C, Seegobin P, Bruno A. An analysis of the global pharmacy workforce capacity trends from 2006 to 2012. *Hum Resour Health*. 2018;16(3):1-9. https://doi.org/10.1186/s12960-018-0267-y.
58. World Health Organization. *Health Workforce Policy and Management in the Context of the COVID-19 Pandemic Response: Interim Guidance, 3 December 2020*. World Health Organization; 2020:29. https://www.who.int/publications/i/item/health-workforce-policy-and-management-in-the-context-of-the-covid-19-pandemic-response.

How to cite this article: Gupta N, Balcom SA, Gulliver A, Witherspoon RL. Health workforce surge capacity during the COVID-19 pandemic and other global respiratory disease outbreaks: A systematic review of health system requirements and responses. *Int J Health Plann Mgmt*. 2021;36(S1):26–41. https://doi.org/10.1002/hpm.3137