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ARTICLE REVIEW

Vulnerabilities to disasters in healthcare facilities in the face of the COVID-19 pandemic: a scoping review

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Abstract *This article maps the structural, nonstructural and functional vulnerabilities of healthcare facilities to the COVID-19 pandemic. It reports on a scoping review guided by JBI recommendations and structured by the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews. The PubMed, CINAHL, LILACS, EMBASE, SciELO, Scopus and Web of Science Repositories and databases were consulted, as was the grey literature. The protocol was registered in the Open Science Framework. The 54 studies included summarised 36 vulnerabilities in three categories in 29 countries. Functional and non-structural vulnerabilities were the most recurrent. Limited material and human resources, service disruption, non-COVID procedures and inadequate training were the items with most impact. COVID-19 exposed nations to the need to strengthen health systems to ensure their resilience in future health crises. Prospective risk management and systematic analysis of health facility vulnerabilities are necessary to ensure greater safety, sustainability and improved standards of preparedness and response to events of this nature.*

Key words *Hospital, Health centre, Vulnerability analysis, COVID-19*

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Introduction

Disasters, regardless of their aetiology, tend to have different magnitudes of impact on different communities and their direct and indirect effects have repercussions on different institutions, sectors and governments. These events can change a region's geographic configuration in seconds, disrupting years of development. Developed countries generally have more resources and are able to restructure more easily than those in the process of development[1]. One emblematic, contemporary example is the COVID-19 pandemic, which has been categorised by risk management experts as a disaster of natural origin and biological type[2].

Given the complex, multifactorial and inter-/transdisciplinary nature of disaster situations, different concepts exist in the technical and scientific literature. This study emphasises the conception presented by the United Nations Office for Disaster Risk Reduction (UNDRR), which considers a disaster to be a serious disruption of the functioning of a community or a society causing widespread human, material, economic or environmental losses which exceed the ability of the affected community or society to cope using its own resources[3].

A disaster, then, is a function of the risk process, which is socially constructed in a process related to the dynamics of development and combines hazards, degree of exposure, conditions of vulnerability and inadequate capacity or measures to reduce adverse outcomes and potential harm[4]. In the light of the above, the COVID-19 pandemic is considered a global disaster, because it combines these elements and requires that strategic sectors focus and articulate various processes from the local to global levels[5].

Commonly, these events alert authorities to activate and implement contingency plans to address such occurrences. The effects extend primarily to infrastructure, services, the local economy and society, which are the bases that underpin the conditions of life. In these emergency situations, the health sector at all levels of government is responsible for providing care to the population, and health services themselves may be prejudiced[6].

In this regard, disaster risk management extends across different kinds of intervention, from policy- and strategy-making to implementation of specific damage reduction and control measures and instruments[7].

Moreover, the uninterrupted operation of health facilities in response to events of this nature can determine the health and survival of large numbers of people. It is thus strategic that these facilities be planned and built in such a way that they resist the impacts of natural and technological phenomena, that their equipment not suffer damage and remain operational, that their lifelines continue to operate and that their personnel are able to continue providing care. In these usually complex and dramatic circumstances, this includes robust sizing and strategic planning of human resources[8].

Accordingly, an international pact "Hospitals Safe from Disasters" was agreed under the coordination of the Pan-American Health Organization. This policy characterises a 'safe hospital' as a health facility, whether large or small, whose services remain accessible and functioning at maximum capacity and within the same infrastructure immediately following a natural disaster. Under this pact, countries commit to ensuring that construction of all new health facilities will meet satisfactory levels of protection and implement appropriate measures to mitigate existing risks[9].

To guide this process, the Hospital Safety Index: Guide for Evaluators[8] established the Hospital Safety Index (HSI), an assessment measure that contemplates the structural, non-structural and functional conditions of health facilities' vulnerability to disasters[9].

Structural vulnerability conditions relate to the supporting portions of the hospital building, such as walls, columns, beams and slabs, failure in one of which can compromise the structure of the building. Non-structural vulnerabilities involve components connected to the building structure, such as windows, ceilings, air conditioning, electrical network, water supply, furniture, equipment and inputs. These provide the basis for the dynamics of a healthcare establishment and relate to hospital infrastructure, working conditions, material resources and equipment. Functional vulnerabilities arise from the distribution of architectural spaces and the relationship between them and the clinical support services offered by the hospital unit. To summarise, proper zoning and correlation between areas of the building can assure effective management dynamics in normal conditions and also in emergency and disaster situations[9].

Following the identification of a new coronavirus in the city of Wuhan, Hubei province, China in 2019[10], and the World Health Organization's recognition of a pandemic[11], governments, institutions and communities began to mobilize

to combat the direct and indirect effects of this disease. Countries of the Americas currently lead the global COVID-19 mortality ratings, with the United States of America (USA) and Brazil ranking highest[12]. Public health measures, however, were not restricted exclusively to severe cases; asymptomatic cases or mild symptoms represented around 80% of total cases[13]. These milder or moderate clinical cases needed to be managed appropriately, requiring that care models in place were consistent with the demands posed by the advancing pandemic[14].

COVID-19's high transmissibility, health system overload from the large numbers of infected and the lack of medicines proven to be effective against the disease highlighted health facilities' vulnerabilities and difficulties in managing this disaster, as shown by the partial collapse of many health systems. Until July 2022 (the study period), the *Coronavirus Resource Center* recorded 553,500,224 confirmed cases and 6,349,732 deaths from the disease worldwide[15].

Overall, short- and long-term planning of actions based on good risk management practices was important in preventing the crisis from worsening[15]. Above all, a better standard of response entailed developing and implementing emergency response plans that considered healthcare facilities' vulnerabilities in order to reduce risk conditions. In that respect, this scoping review mapped healthcare facilities' structural, non-structural and functional vulnerabilities to the COVID-19 pandemic.

For that purpose, a preliminary search for reviews of similar scope to that objective was carried out in MEDLINE (via PubMed), JBI Database of Systematic Reviews and Implementation Reports and in the Cochrane Database of Systematic Reviews. No reviews with the same purposes were identified, making this study opportune.

Methods

This scoping review is structured according to JBI recommendations and used the Preferred Reporting Items for Systematic Reviews and Meta-Analyses extension for Scoping Reviews (PRISMA-ScR) as a matrix for preparing the study report[16-17]. The research protocol was registered in the Open Science Framework (OSF) and can be consulted at: https://osf.io/3hkr6/.

Research question

The PCC mnemonic (P – Population/Participants, C – Concept and C – Context) was used to construct the following review question: "What structural, non-structural and functional vulnerabilities of health facilities were identified during the response to the COVID-19 pandemic?"

Eligibility criteria

*Participants: a*ll types of facilities that provided health services to the public during the COVID-19 pandemic were included.

*Concept: t*he concept was based on the structural, non-structural and functional vulnerabilities that health services displayed. These posed challenges or problems that impaired and/or prevented health practices in response to the pandemic. Vulnerabilities were categorized by the items assessed in the Pan American Health Organization's "Hospital Safety Index: Guide for Evaluators" (PAHO/WHO)[8].

Context: the context was limited to the COVID-19 pandemic, from March 2020 to July 2022. Studies outside the timeframe of the response to the pandemic, even if addressing similar biological disaster situations, were not considered.

Source types: this scoping review considered primary studies (original research) and secondary studies (systematic and non-systematic reviews) published, or not published, in national and international portals, repositories and databases. Duplicate studies, those without the full text and abstracts published in event annals were not considered.

Search strategy: initially, controlled (MeSH, DeCS and EMTREE) and uncontrolled descriptors, formulated from keywords of the research question and including "Health Services", "Centros de Saúde", "Hospitals", "Vulnerability Analysis" and "COVID-19", were identified and used to construct the initial search strategy. With the help of librarians, the search strategies were refined and adapted for each database/data repository searched.

The data sources searched were PubMed, CINAHL, LILACS (via VHL), EMBASE, SciELO, Scopus and Web of Science. For the grey literature, Epistemonikos ("Database of the best of Evidence-Based Health Care, Information Technologies and a Network of Experts") was used, in conjunction with the academic search engine, Google Scholar.

Study selection and screening: selection took place in July 2022 and, after the searches, all records identified were grouped and imported into Rayyan (Qatar Computing Research Institute, Doha, Qatar)[18]. First, duplicates were removed, then records were screened by title and abstract and, lastly, the full text and references of the selected articles were examined. Titles and abstracts, as well as studies from the reference lists, were selected by two independent, blinded reviewers, who evaluated the studies against the eligibility criteria. At all stages of screening, a third reviewer was consulted to resolve any conflicts by examining the studies and inclusion criteria.

The exclusion criteria were: studies off the topic addressed, either because for not addressing health services and/or impacts and vulnerabilities from the COVID-19 pandemic disaster; studies outside the time frame, that is, before 2020; duplicate studies or those lacking the full text; and abstracts published in event annals.

*Data extraction: g*eneral data relating to identifying studies, and specific data on participants, concept and context, were collected from the articles included in this scoping review using a specific data extraction instrument developed in the form of a Microsoft Excel® spreadsheet in line with the review objective. The extracted data included authors, year of publication, title, country, language, type of document, journal, research funding, method and concepts of interest to the study. The instrument for extracting vulnerabilities was modified by the authors in the course of the process by adding subcategories to adapt it to the information collected. It was unnecessary to request additional information or clarifications about the data from the authors of the articles included.

Data analysis and presentation: the extracted data were allocated and analysed by way of Excel® spreadsheets, according to the previously defined extraction instruments. From the data analysis, illustrations were developed in Word, Lucidchart and Canva.

Results

Of a total of 3,226 studies selected for screening, only 127 articles were considered potentially relevant. Reading of the full texts found 51 to be off concept, 21 lay outside the specified population and full texts were not available for eight. In the end, 54 articles were included in this review, seven of them extracted from study reference lists. The results of the study screening and selection process are summarized in a PRISMA flowchart (Figure 1).

General characteristics of the studies

On examining the 54 studies included (Table 1), all were found to be produced by different authors and all were available in English. The year with most publications was 2021 (46.3%); and some had no funding of any kind (42.5%). By document type, 35 (64.8%) were original research articles, six (11.1%) were perspectives, while the other 13 studies took the form of comments (7.4%), pre-print (5.5%), point of view and brief communication (3.7%) and editorial, opinion and analysis (1.8%). Forty-two (77.7%) were published in different journals, of which *PLoS ONE* and *Research Square,* with three (5.5%) publications each, published the most on the subject.

The countries most mentioned were the USA (10.5% of studies), India (8.7%) and Brazil and Pakistan (7.0%). Three studies were not geographically delimited. However, countries from the five continents were reported in the studies selected. The table below summarises the main findings.

Most of the studies took a quantitative approach, were of an exploratory or descriptive type and used field research methodology (22.2%). Data was generally collected by way of observations, interviews or forms. The studies commonly focused on analysing and quantifying how services were affected by the COVID-19 pandemic. Meanwhile observational (case, cohort and cross-sectional) and qualitative studies accounted for 11.1% of the total. These publications recorded lived experiences or empirical opinions during the event and made risk management recommendations.

Vulnerabilities

For each type of structural, non-structural or functional vulnerability, subcategories were created by items assessed in the HSI (Chart 1). The 11 items established in this way were: condition of the building; condition and safety of healthcare personnel; condition and safety of medical and laboratory equipment and supplies; operation of lifelines; hospital capacity; condition of access roads to the hospital; services provision; health workforce; health information systems; health sector management; and management of COVID-19.

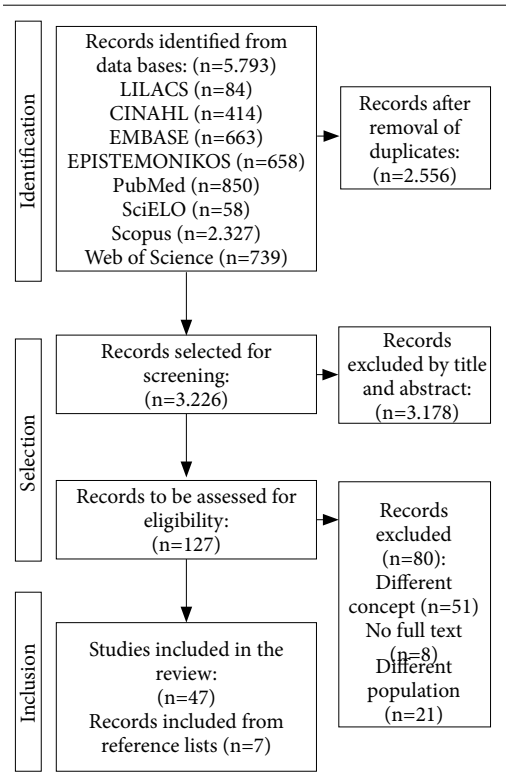

Figure 1. PRISMA flow diagram of the study selection process.

Source: Authors.

In total, 36 vulnerabilities were identified in structural, non-structural and functional components of health facilities/services. In the course of the review, there were 300 mentions, the most frequent being: limited material (13.3%) and human (8.6%) resources, interruption of non-COVID health services/procedures and inadequate training (7.6%), limited testing capacity (6.0%), inadequate personnel wellbeing strategies (5.3%), inadequate infection prevention and control (5.0%), insufficient beds (4.6%), inadequate facilities for COVID-19 patients (4.3%) and limited surge capacity (4%).

The vulnerabilities most mentioned were grouped in an Ishikawa diagram (Figure 2), representing the causes and effects of the main vulnerabilities to disasters that healthcare facilities faced in responding to the COVID-19 pandemic.

Discussion

This review of 54 studies involving 29 countries summarised a number of vulnerabilities displayed by hospital systems, departments, health services and other institutions in the context of the COVID-19 pandemic, which exposed how unprepared health systems were to respond to a biological disaster of this nature, even in more developed countries.

Structural vulnerabilities

Condition of the building

To be able to respond to a disaster, a healthcare facility needs to be in full working order and have resilient infrastructure. However, according to the 2021 Global Health Security Index, no country was prepared to manage a catastrophe effectively, including epidemics and pandemics. Its report recorded an overall average country score of 38.9 out of 100[19].

In this review, four studies reported deterioration of facilities in health services in Brazil, Ecuador, Colombia, Haiti, Jordan and Pakistan[20-22].

Historically, developing countries, because of their poor health infrastructure and undeveloped technologies for preventing epidemics, have greater difficulty in absorbing the impacts of public health emergencies[22]. One study showed that most hospitals and healthcare facilities in Asia and Africa were not designed to deal with highly infectious diseases, as in the MERS, Ebola and SARS outbreaks[22].

Non-structural vulnerabilities

Conditions and safety of healthcare staff and supplies

One of the biggest challenges posed by the COVID-19 pandemic was supply shortages, as demonstrated in several studies. Even the wealthiest countries suffered from shortages of personal protective equipment (PPE), supplies (medicines and disinfectants), as well as assisted ventilation equipment[23,24]. In Italy, healthcare personnel experienced high rates of infection and death, connected in part with inadequate access to PPE[24]. In certain emergencies and disasters involving infectious diseases, these resources are essential to providing safe care and protecting frontline healthcare personnel.

Limited material resources, the most frequent COVID-19 impact, was reported in 40 studies. Lack of PPE was prevalent among ser-

Table 1. Summary of study parameters.

Countries most mentioned	USA	7	Language	English	52
	India	5		Portuguese English	1
	Brazil	4		Russian/English	1
	Pakistan	4	Financing	Yes	17
	Canada	3		No	23
	Nigeria	3		Not informed	14
	South Africa	2	Methods most used	Exploratory quantitative field research	6
	Bangladesh	2		Descriptive quantitative field research	6
	China	2		Descriptive qualitative observational research	6
	Spain	2		Descriptive quantitative observational research	4
	Indonesia	2		Descriptive quantitative bibliographical research	4
	Italy	2		Descriptive quantitative documentary research	3
	Not applicable	14		Exploratory quantitative experimental research	3
Document Type	Article	35		Exploratory quantitative bibliographic research	2
	Perspective	6		Descriptive qualitative phenomenological research	2
	Comment	4		Descriptive qualitative field research	2
	Article/ Pre-print	3		Descriptive quantitative experimental research	2
	Comunicação breve	2		Qualitative exploratory observational research	2
				ResearchSquare	12
	Brief communication	2	Magazines that published the most	*PLoS ONE*	3
	Point of view	1		*Frontiers in Public Health*	3
	Opinion and analysis	1		*Journal of Health Management*	2
Ano	2021	25		*The International Journal of Health Planning and Management*	2
	2020	18		Outros	2
	2022	11			42

Source: Authors.

vices, especially during the first wave of the pandemic, when nations were practically fighting for this equipment on the global market[25]. However, as pointed out in some studies, lack of PPE was already a chronic condition, especially in the poorest countries, such as in West Africa. This led to a critical scenario of rationing during the pandemic, demonstrating the extent to which the most vulnerable populations were exposed and lacked care[25,26].

Health personnel were undeniably one of the crucial pillars in endeavours to combat a disease that was still unknown and whose progression was unpredictable; nonetheless, they still saved thousands of lives. Even though previous experience showed that this profession is among those that engage and suffer most during emergencies and disasters[27,28], measures to ensure decent, safe working conditions are still largely unknown.

Sixteen studies reported inadequate strategies for health personnel's wellbeing as a non-structural vulnerability. To a point, this indicates a poor supply of physical and material measures to alleviate job stress and discomfort. Environments with poor air-conditioning or lacking efficient ventilation, appropriate areas to rest or work and places for hygiene, donning or doffing, in addition to lack of PPE and necessary supplies for clinical patient management, were some of the challenges highlighted[21].

Hospital capacity

Another point emphasised among non-structural vulnerabilities was healthcare sectors' inability to adjust to the increasing numbers of hospital admissions. In order to limit and control local transmission, rigorous detection, prevention and control measures were necessary, including rapid identification of suspected cases, isolation of patients and rapid diagnosis[29]. However, application of a vast framework of technical

Chart 1. Categorization of vulnerabilities found.

Classification	Subcategory	Vulnerability	Total
Structural	Condition of the building	Deteriorated healthcare facility	4
Subtotal:	1	1	4
Non-Structural	Condition and safety of healthcare personnel	Inadequate personnel wellbeing strategies	16
	Condition and safety of medical, laboratory equipment and supplies	Limited material resources	40
		Poor quality healthcare supplies	3
		Procurement of counterfeit medicines	1
	Operation of lifelines	Inadequate medical gas storage	4
		Inadequate water supply system	2
		Inadequate ventilation system	1
		Inadequate electrical supply system	1
		Inadequate air conditioning system	1
	Hospital capacity	Limited testing capacity	18
		Insufficient beds	14
		Installations unsuitable for COVID-19 patients	13
		Limited surge capacity	12
		Overcrowded	8
		Inadequate laboratory services	4
		Inadequate supply chain management	2
		Shortage of mental health installations	1
		Lack of cold chain installations	1
		Inadequate biomedical waste management	1
	Condition of hospital access roads	Blockage of roads leading to the hospital	1
Subtotal:	5	20	144
Functional	Service provision	Disruption of non-COVID healthcare services/ procedures	23
		Limited supply transportation logistics	2
	Health personnel	Limited human resources	26
		Inadequate personnel training	23
		Inadequate personnel management	9
		Psychological impacts	6
	Health information systems	Inadequate health information and communication services	3
		Cyber-risk/vulnerable hospital data	2
	Health sector management	Inadequate inter-sector coordination	9
		Inadequate pandemic preparedness	9
		Inadequate financial resources	7
	COVID-19 management	Inadequate infection prevention and control	15
		Inadequate COVID-19 clinical management protocols and flows	9
		Inadequate COVID-19 care logistics	7
		Use of medicine without clinical evidence	2
Subtotal	5	15	146
Total:	11	36	300

Source: Authors.

and operational interventions depends on each country's infrastructure and laboratory and public health resources[30].

Problems involving inappropriate installations for COVID-19 patients were reported by 13 studies. This means that, in critical sectors of hos-

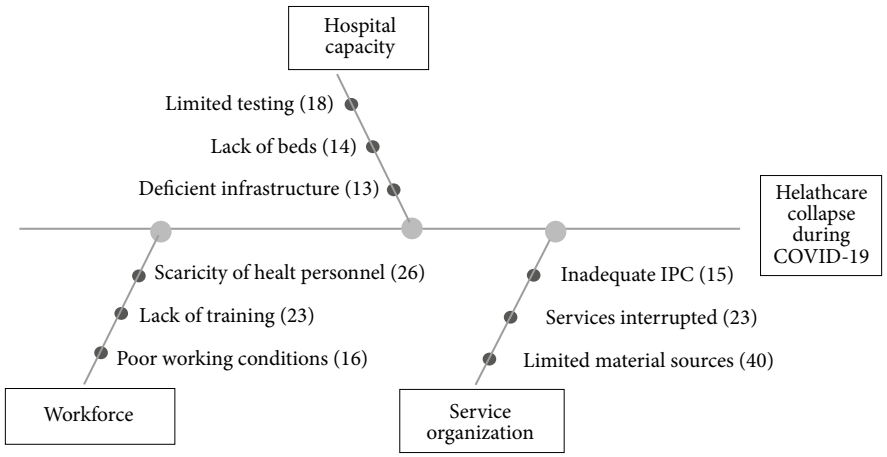

Figure 2. Main vulnerabilities.

Source: Authors.

pitals, such as intensive care units (ICUs), devices and/or technologies were absent or inadequate. Some studies reported that their sectors lacked a separate area for screening or that it was improvised[31,32]. Areas for isolating COVID-19 patients were adaptations not architecturally designed to accommodate patients with diseases transmitted by droplets or aerosols[31-34]. Another important aspect was the absence of areas for hand hygiene[31], conduct that is crucial to avoiding cross-transmission in hospital environments[34].

"Surge capacity" was another challenge recorded in 12 studies, which explained that patient demand was much greater than health service supply could meet. The geographic distribution of healthcare facilities was also an important factor: areas further from urban centres tended to lack of healthcare facilities capable of serving their whole population[35].

Insufficient numbers of beds led health facilities to operate at maximum installed capacity, as recorded in 14 studies. Estimates indicate that, in Bangladesh, 0.7 ICU beds were available per 100,000 inhabitants, while the average in Asian countries is 3.6[36]. In any case, although bed numbers were an important parameter during the pandemic, the literature shows that care provision during the event was also affected by other factors, including scarcity of material resources and specialists[24,37,38].

Another aspect to be considered was limited testing capacity and inadequate laboratory services. Inadequate COVID-19 testing was the most common problem in this subcategory. This underlines the importance of testing in screening for, and diagnosing, suspected cases, as observed in studies in South Korea, Vietnam and China[39-41].

Some studies revealed that the reasons for failures in the testing process included the limited number of laboratories, lack of kits or other supplies, delays in sample processing, underreporting, improper sample management and the people's refusal or fear of testing. Moreover, some studies also reported challenges in sample handling, storage and transportation in services, as well as a lack of other laboratory services and technical competence for these purposes.

Functional vulnerabilities

Service provision and workforce in the health sector

With COVID-19 cases imminent, healthcare services were forced to reduce or interrupt non-essential procedures so as to allocate all their resources to combating the pandemic. Interruption of non-COVID services or procedures was recorded 23 times. This led to a decrease in elective surgery slots, screening procedures, triages, diagnoses and so on. Even two years after the start of the pandemic, the WHO reported healthcare facilities in 90% of countries surveyed were still suffering from continual disruptions to essential services[43]. In Italy, the pandemic caused interruptions, delays, reductions and cancella-

tions of maternity and neonatal consultations in 70% of mother and child health institutions[44].

The root causes of most of these interruptions recorded in the studies were "limited human resources", "inadequate training", "inadequate staff management" and "psychological impacts". These health workforce vulnerabilities also impaired service provision, so much so that services finding difficulty in managing work teams and in receiving support sufficient to meet the large demands were described in most of the studies cited. The difficulty most mentioned was limited human resources, meaning the shortage of qualified health personnel in health services and the need for strategic planning and plausible scaling of human resources.

Notably, one study of healthcare working conditions during COVID-19 in Brazil found that 43.3% of personnel felt unprotected against COVID-19 and that the main reason was limited access to PPE[45].

These factors connect with the psychological impacts caused by high workload and ineffective management, resulting in high levels of stress and exhaustion from the chaotic situation never before experienced in ICUs. Publications list high rates of burnout, depressive symptoms, sleep disorders and anxiety among these staffs. PAHO recommended that facilities' contingency plans provide necessary psychological support measures for health personnel[8].

Many records noted that healthcare personnel also lacked sufficient technical knowledge to deal with critically ill patients. Unpreparedness was a common situation in most countries affected, such as Spain, where around 54% of primary care personnel did not receive appropriate training in donning and doffing[46,47].

Health sector management and managing COVID-19

According to PAHO, hospitals need to have a guaranteed, budgeted financial reserve for emergencies[8]. However, seven studies in low- to high-income countries reported limited funding as among the challenges to health management. Research has attributed this difficulty to both the reduction in clinical care and non-COVID services and to pre-existing chronic underfunding internationally.

Another difficulty highlighted was the need to prepare the health sector to face future biological disasters, as attested in publications that exposed inadequate levels of preparedness and inter-sector coordination to address the pandemic.

In short, research has demonstrated that hospitals lacked contingency plans, rapid response teams, crisis offices and multi-sector risk communication. It was recommended that Pakistan, for example, develop an outbreak detection and control system, as it scored zero in emergency preparedness and response planning on the 2019 Global Health Security Index[48].-

As regards infection prevention and control, studies summarized the main problems as resulting from suboptimal working conditions, including lack of hospital supplies and equipment and knowledge gaps among frontline workers with little or no ICU experience. Among the first cases of COVID-19 in Wuhan, China, 29% of patients were members of the hospital workforce, showing that infection prevention protocols in force at the time were insufficient to contain the spread of the virus[49]. Others issues included reuse and inappropriate use of PPE, when this was available.

Added to this was staffs' lack of knowledge or unpreparedness regarding COVID-19 clinical management protocols. As this was a new disease, clinical treatment and diagnosis guidelines changed frequently with new research findings. Meanwhile, implementation of protocols was also hampered by technical, logistical and stock constraints.

Two studies reported the use of scientifically unproven medicines, such as hydroxychloroquine and antiretrovirals. Despite the lack of scientific support, political leaders in American countries, such as Brazil and the USA, produced, stockpiled and encouraged the use of these drugs to treat COVID-19[42], raising serious human safety concerns in the scientific community. This also limited stocks for patients making recommended use of the medicines to treat other clinical conditions[50].

Conclusion

The COVID-19 pandemic exposed nations' need to strengthen health systems to ensure their resilience, especially against similar health crises in the future. In the throes of this global disaster, the constraints imposed by resource scarcity accentuated existing problems, such as deficient health infrastructure in both high- and low-income communities, which further hampered attempts to respond to this disaster and the unprecedented challenges it raised. Prevalent functional vulnerabilities significantly affected service provision, underscoring the importance of engaging qual-

ified health personnel, providing continued professional development for those already working in health facilities and ensuring appropriate working conditions so that clinical practices can operated safely and with appropriate quality, all of which is guaranteed by sound strategic human resource planning to respond to disasters.

It is recommended that recommendations for the construction of disaster-resilient buildings of whatever type be considered within the scope of projects for new healthcare facilities. Moreover, existing facilities need to implement systematic vulnerability analysis processes, with a view to prospective risk management and adaptation to current security standards.

More research is needed into the HIS's applicability in different types of healthcare facilities besides hospitals, because the list of vulnerabilities contemplated in the document is limited and does not include all existing models of healthcare facility, with a view to strengthening local resilience and developing a culture of hospitals safe from disasters.

Collaborations

All authors of the article contributed substantially, directly and jointly, to data collection, analysis and interpretation, as well as to writing the manuscript, critically reviewing the content and approving the final version.

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