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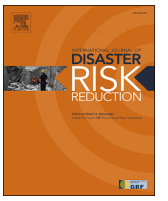

Primary health care disaster preparedness: A review of the literature and the proposal of a new framework

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ABSTRACT

With the publication of the Health Emergency and Disaster Risk Management (H-EDRM) Framework in 2019, the World Health Organization (WHO) emphasized the need for disaster preparedness in all sectors of the health system, including primary health care (PHC). PHC disaster preparedness plays a crucial role in guaranteeing continuity of care and responding to the health needs of vulnerable populations during disasters. While this is universally acknowledged as an important component of disaster management (DM), there is still a severe paucity of scholarship addressing how to practically ensure that a PHC system is prepared for disasters. The objective of this study is to propose a new framework that describes key characteristics for PHC disaster preparedness and lays the groundwork to deliver operational recommendations to assess and improve PHC disaster preparedness. A systematic literature review was performed and a total of 145 records were analyzed. Twenty-five characteristics that contribute to a well-prepared PHC system were identified and categorized according to the WHO Health System Building Blocks to form a new PHC disaster preparedness framework. The findings will contribute to the elaboration of a set of guidelines for PHC systems to follow in order to assess and then boost their disaster preparedness. This manuscript will hopefully help to raise awareness among international policymakers and health practitioners on the importance to design interventions that integrate the PHC system into overall DM strategies, as well as to assess the preparedness of PHC systems in different political, developmental, and cultural contexts.

Abbreviations

H-EDRM	Health Emergency and Disaster Risk Management
WHO	World Health Organization

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DM	Disaster Management
PHC	Primary Health Care
LAMIC	Low and middle income countries
HIC	High income countries
HIS	Hospital Safety Index
CHWs	Community Health Workers
HIS	Health Information System

1. Introduction

In recent years, a new comprehensive approach to disaster management (DM) has been developed, emphasizing prevention and preparedness strategies and efficient coordination of resources and information [1]. In 2019, the World Health Organization (WHO) published the Health Emergency and Disaster Risk Management (H-EDRM) Framework, which points out the pivotal role of health in DM and sets out comprehensive guidelines for building resilient health infrastructures and reducing the health risks and consequences of emergencies and disasters [2]. The H-EDRM framework brings together ideas from previous international instruments aimed at enhancing health disaster preparedness, namely the International Health Regulations [3], the Sendai Framework for Disaster Risk Reduction 2015–2030 [4], the Paris Agreement on Climate Change [5], and the Sustainable Development Goals 2015–2030 [6]. It, thus, offers an integrated strategy for resource and knowledge management vis-a-vis current and emergent public health risks and promotes coordinated planning and action in the event of a disaster. Although emergency services have historically been the loci of DM, the H-EDRM guidelines highlight the important roles and functions played by primary health care (PHC) services in response to disasters and underscore the need to integrate them into countries' disaster and emergency management [2].

Since the signing of the Alma-Ata Declaration of 1978, PHC has been recognized as the key factor necessary for reaching the goal of *Health For All*. Conceptual understanding and importance of PHC were re-emphasized in the 2008 World Health Report *PHC Now more than ever* that re-focused the world's attention to PHC's unique characteristics [7]: 1) typically, it is patients' first point of access to health care provision, and it provides long-term, person-centered, coordinated and comprehensive care; 2) it encompasses several essential public health functions such as health promotion, preventative care, and health protection; 3) it plays a crucial role in addressing inequities and challenges that arise in the provision of health care for marginalized and vulnerable populations; 4) PHC practitioners generally have an intimate view of patients' lives and needs, which allows them to understand the impact of social determinants of health (e.g., employment, housing). These factors enable PHC facilities to deliver the continuous provision of optimal, low-cost medical assistance in the event of a disaster [7,8]. This is particularly true for marginalized and vulnerable populations, who are at greater risk of suffering adverse health outcomes when a disaster takes place. PHC plays an important role in proactive engagement and appropriate communication within these communities. This supports an effective emergency response but also empowers communities to anticipate and identify potential risks [9].

There is a growing body of literature pointing a spotlight on the critical role played by PHC in DM, particularly in maintaining community health in times of crisis [10–13]. In 2018, the WHO published the report *Primary health care and health emergencies*, calling for a renewed commitment to promote PHC to improve health outcomes of people during disasters [14].

Although PHC seems to play a crucial role in DM, there remains a severe paucity of research addressing how to practically ensure PHC disaster preparedness. Furthermore, to the best our knowledge, consideration of PHC disaster preparedness within national DM plans is still scarce. The objective of this study is to propose a new framework that describes key characteristics for PHC disaster preparedness and lays the groundwork to deliver operational recommendations to assess and improve PHC disaster preparedness.

2. Methodology

This review was conducted in March 2022 in accordance with the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA) Checklist. The following online scientific databases were searched: Cochrane Library, Embase, Medline, National Library of Medicine, PubMed, Scopus, and Web of Science. Gray literature was also found by searching in: Trove, Mednar, and OpenGray. The researchers also hand-searched and scanned reference lists to locate pertinent articles not indexed in databases. All articles included in the review had to be published in English since the start of 2008, when the WHO released its report *PHC now more than ever*.

We conducted database searches for articles containing a combination of terms related to PHC (*primary healthcare*, *primary health care*, or *primary care*) and DM (*disaster preparedness, emergency preparedness, disaster management,* and *risk reduction*) in their titles, abstracts, or lists of keywords. In order to obtain as comprehensive an overview of the subject as possible, no restrictions were applied with regard to study type. The retrieved articles were then imported into Mendeley Reference Manager to identify duplicates and keep track of the screening process.

The resulting articles were then analyzed by date of publication, type of hazard, economic context, and study type. Following, the authors reviewed the articles' content to identify which specific characteristics of a PHC system contribute to disaster preparedness. A tally was carried out to determine how many of the articles mentioned each of these characteristics. An inductive analytic approach was then used to group these characteristics into thematic clusters, arranged according to the WHO's Health System Building Blocks [15].

3. Results

A total of 568 records were initially identified through database searches. The removal of duplicates (n = 332) left 236 articles to be judged for relevance. Of those, 132 were excluded upon review of titles and abstracts, and 6 were excluded because of unretrievable full text, leaving 98 reports culled from databases. Another 47 records that met the inclusion criteria were identified through other search methods, bringing the total number of articles included in the study to 145 (see Fig. 1).

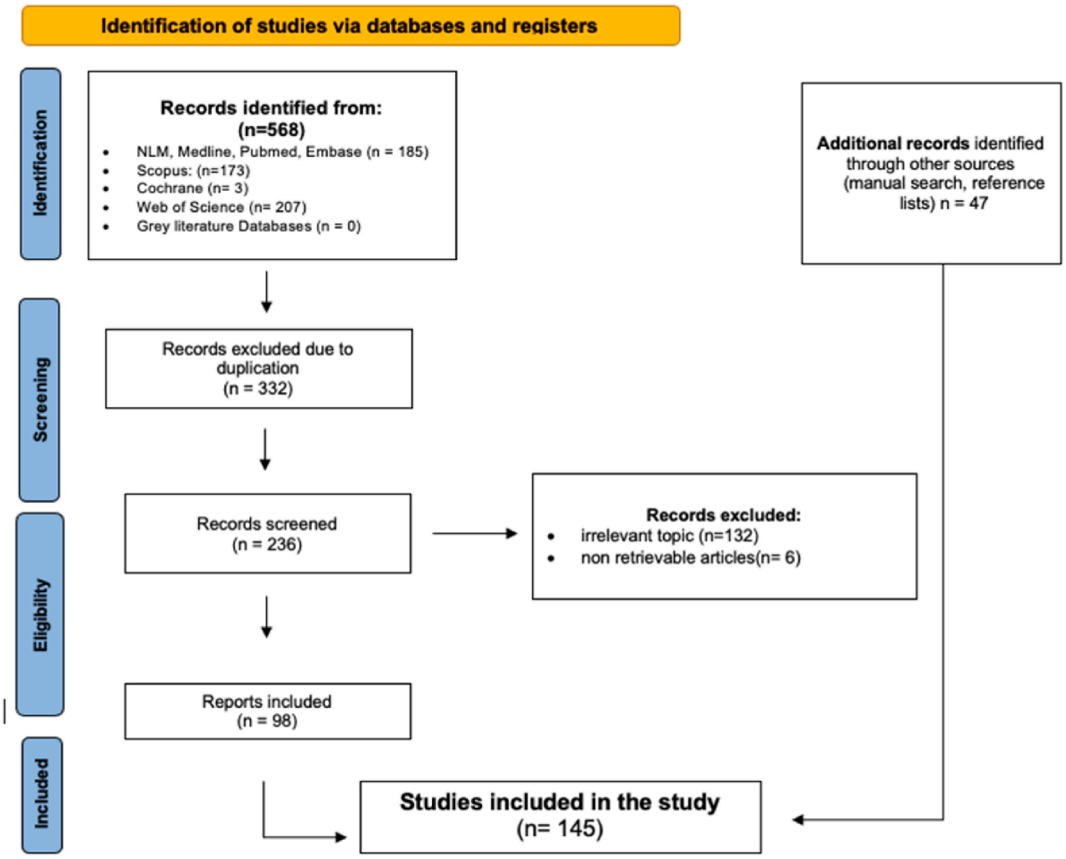
3.1. Overview of the retrieved articles

In 2008, only a few articles were published. However, the amount of research on PHC preparedness saw a sharp increase following the 2011 tsunami and the subsequent nuclear disaster in Fukushima (Japan) and the spread of COVID-19 in 2020 (Fig. 2).

Over 39% of the articles reported of an all-hazard approach to disaster preparedness at the PHC level. Studies about preparedness for disasters caused by geophysical/hydrometeorological (25%), and biological hazards (12%) were also well represented. While 47% of the articles focused on high income countries (HIC), predominantly in the United States (US), only 30% examined PHC preparedness in low- and middle-income countries (LAMIC), and 23% elaborated on the topic in a global context (Table 1). Table 2 shows the types of articles reviewed.

3.2. PHC disaster preparedness framework

Twenty-five characteristics that contribute to a well-prepared PHC system were identified in the literature. These characteristics have been grouped into fourteen thematic clusters (white boxes), which in turn have been arranged according to the WHO Building Blocks (upper boxes) (Fig. 3).



Tricco, AC, Lillie, E, Zarin, W, O'Brien, KK, Colquhoun, H, Levac, D, Moher, D, Peters, MD, Horsley, T, Weeks, L, Hempel, S et al. PRISMA extension for scoping reviews (PRISMA-ScR): checklist and explanation. Ann Intern Med. 2018,169(7):467-473. doi:10.7326/M18-0850.

Fig. 1. Identification of studies. Adapted from PRISMA extension for scoping reviews (PRISMA-ScR).

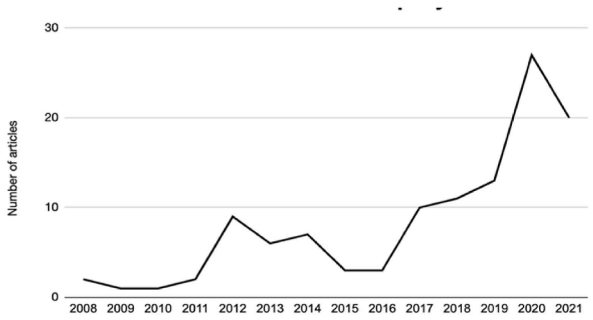


Fig. 2. Number of reviewed articles, per year.

Table 1
Number of articles reviewed, per type of hazard and context analyzed.

	All-Hazard	Geophysical, hydrometeorological	Biological		Human-induced (technological, societal)	Total
			COVID-19	Others		
Global	17	1	11	3	3	**35**
HIC	31	14	11	9	2	**67**
LAMIC	12	16	5	8	2	**43**
Total	**60**	**31**	**27**	**20**	**7**	**145**

Table 2
Type of articles reviewed.

Original studies		
Quantitative studies **n = 43**	Experimental n = 4	- Non randomized control trials = 3 - Randomized control trials = 1
	Observational n = 39	- Surveys = 27 - Analysis of secondary data = 12
Qualitative studies **n = 22**	- Interview-based = 15 - Surveys = 3 - Focus group discussions = 2 - Document analysis = 2	
Mixed methods **n = 24**	- Surveys + interviews = 9 - Survey + focus group discussions = 2 - Interviews + focus group discussions = 2 - Analysis of secondary data + focus group discussions = 1 - Analysis of secondary data + interviews = 1 - Other combinations = 7	
Literature Reviews	N = 14	
Expert opinions		
Commentaries, letters to Editors, brief reports, editorials	N = 42	

Table 3 lists each characteristic, grouped by building block and thematic cluster, alongside the number of articles that addressed such characteristic.

3.2.1. Leadership and governance

3.2.1.1. Policy planning. Despite the important role that the PHC system plays during disasters, clear policies regarding PHC functions and roles in DM are either lacking or underdeveloped [16–20]. However, policy level solutions to optimize PHC system preparedness were found in the literature. Many articles (n = 24) encourage the creation of a comprehensive *whole-of-society* disaster preparedness plan that integrates all components of the health sector. Establishing such a comprehensive preparedness plan is contingent upon having a clear governance structure capable of coordinating action across multiple institutions (i.e., hospitals, emergency services, PHC, public health agencies, pharmacies, non-profit and community organizations, supply chain logistics) [17,18,21–42]. Integrating the PHC system into broader disaster management plans effectively reduces community disaster risk and avoids redundancies and inefficiencies [17,21,22,25–28,32,33,35–38,43–63]. Disaster management plans for the PHC system should be tailored to respond to different types of disasters, namely those caused by natural, human induced and environmental hazards [32,39,40,64,65]. Many sources (n = 40) called for national policies to include specific directives for the efficient coordination of PHC providers with other sectors by creating: 1) a memorandum of understanding with public health authorities for surveillance, early warning, identification of cases, contact-tracing; 2) clear referral procedures between PHC facilities and hospitals for the transfer and discharge of patients; 3) arrangements with local non-governmental organizations (NGOs), pharmacies, volunteer organizations, and transportation agencies [18,21,22,25,26,28–40,44,56,57,59–62,65–79].

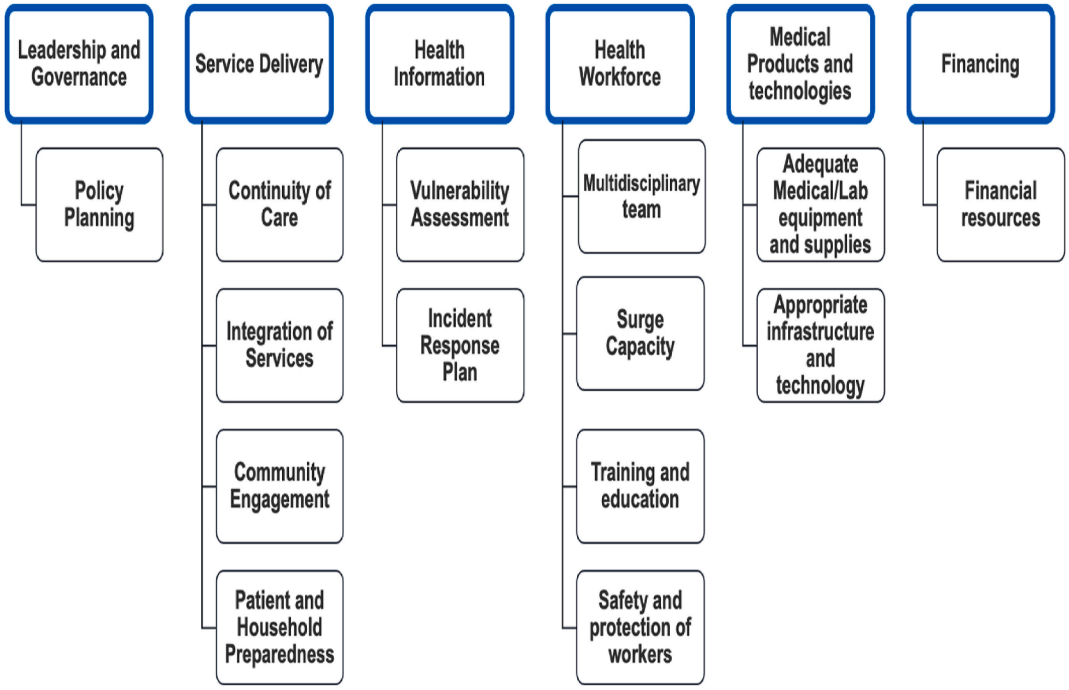


Fig. 3. *PHC disaster preparedness framework.*

3.2.2. Service delivery

3.2.2.1. Continuity of care. The importance of granting continuity of operations during disasters was a topic that arose in many of the reviewed sources (n = 62) [16,18,22,23,25,27,28,32–34,37,41,49,51–53,56,57,59,64–67,69,73,74,77,78,80–113]. Health systems should be ready to employ multiple strategies to ensure that patient care is not disrupted. A multipronged approach is necessary because of the wide variety of factors that could result in a disruption of care (Table 4). While all the factors in Table 4 have an effect on the continuity of care, some strategies are explored in other sections, as noted.

Three policy recommendations emerged in the literature for avoiding disruption of care due to staff shortages. First, health professionals who attend training in DM are more likely to attend work during emergencies [81]. Hence, the nation-wide education and accreditation system for PHC professionals should include basic knowledge of disaster medicine and how to continue service delivery during a disaster [23,25,28,32,40,61,62,76,77,82,87,92,114]. Second, having policies on the books that ensure the safety of workers and their families encourages health professionals and support staff to attend work during disasters [28,81]. The state should, thus, prioritize the occupational health of PHC workers through clear strategies in place to protect the safety and well-being of all cadres of healthcare workers and their families during disasters [28,32,64,73,78,90,115–117]. Third, plans should be in place allowing professionals to nimbly move between roles and institutions, as the needs for different types of expertise may evolve over a territory as a disaster develops. In practice, plans should explicitly describe how and when it is optimal for nurses and other caregivers (e.g., community health workers) to transition into other more physician-like roles after adequate training [25,41,102]. Additionally, there should be a plan for personnel to move between different public and private health institutions as surge support during disasters [67,73,74]. This would allow healthcare professionals to temporarily go where they are most needed.

Nine articles examine the structural barriers to healthcare access that exacerbate the vulnerability of certain categories of individuals during disasters. This is due to a combination of factors that make healthcare access out of reach both legally and/or financially for the affected persons (lack of entitlement to registration in a national health system, lack of enrollment in insurance programs and lack of funds for out-of-pocket expenses) [28,37,52,53,58,69,82,100,118]. To tackle this issue, practical strategies and interventions designed to target vulnerable populations should guarantee access to both basic and emergency services for everyone during disasters. For example, during the H1N1 pandemic in Canada in 2009, access to basic care was granted to every individual regardless of their legal status or registration to the national health system [52].

Alternative models of care delivery can be implemented at the local level to avoid disaster-related disruption of operations [16,25,52,53,64,77,89]. These models include modifying practice operating hours, extending consultation length, working outside the usual medical facility – e.g.. in evacuation centers, community buildings, rural hospital emergency departments, mobile clinics, or at the site of the incident. Similarly, home-based care during disasters has been associated with reducing unmet needs and financial costs while improving outcomes for fragile populations [45,86]. Another important tool for reducing care disruption and increasing access to services during disasters is telemedicine [20,35,39,53,61,68,69,75,82,88,91,98,106,119,120], particularly in geographically hard-to-reach communities [18,33,59,86]. It can provide comprehensive and continuous access for those requiring routine care for chronic health needs, including psycho-social care [51,67,73,121]. Granting access to telemedicine in under-resourced settings

Table 3
Identification of characteristics for PHC-preparedness and frequency of appearance in the reviewed articles.

Leadership and governance	N. Papers
Policy planning	
Unified strategy of disaster management: whole-of-society approach with clear governance structure	24
Integration of PHC into disaster and emergency management policies	35
Context-specific all-hazard approach	5
Coordination of PHC providers with other sectors	40
Service delivery	
Continuity of care	
National policies should mandate how PHC operates to grant continuity of care	62
Alternative models of care	7
Telemedicine	15
Integration of services	
Integration of routine with emergency services	56
Integration with Public Health functions	27
Community Engagement	
Disaster preparedness strategies at the community level	36
Outreach initiatives	19
Collaboration with other community-based services (coalitions)	12
Patient and household preparedness	
Involve patients and households to improve their disaster health risk literacy and empowerment; involve them in the co-management of their health	29
Health information	
Vulnerability assessment	
Vulnerability Assessment conducted in the preparedness phase	27
Incident response plan	
Every PHC facility should adopt a clear incident response plan	16
Health workforce	
Multidisciplinary team	
Multidisciplinarity is fundamental for building optimal disaster preparedness strategies	14
Critical role of community health workers	19
Surge capacity	
PHC's role in extending the capacity of hospital and emergency departments	12
Training and education	
Disaster education program should be present for healthcare professionals at the PHC level	40
Safety and protection of workers	
Physical and Mental safety and protection of all PHC professionals should be prioritized to grant preparedness and continuity of care	17
Medical Products & Technologies	
Appropriate Medical and Lab equipment and supplies	
Inventoried list of medicines, supplies and devices (or lab equipment)	12
Infrastructure and technology	
Safety assessment of physical infrastructure	8
Robust Health Information System	11
Fully functional telecommunications with backup	8
Financing	
Adequate allocation of financial resources	11

represents the biggest challenge so far for a broad implementation of such strategy. It requires substantial efforts from national policies and governments to overcome such challenges [33,67]. Further research is needed to understand the full potential of how telemedicine-based interventions can minimize disruptions to primary care in disaster-settings [122].

3.2.2.2. Integration of services. The literature (n = 56) shows that facilities are more effective at preventing negative patient outcomes during a disaster when they integrate emergency health services into the existing PHC infrastructure [18,22,24–27,29,30,34–36,39,43,53–55,59,61,66,69,71,75,76,79,80,83,85,87–106,108,112,114,115,123–127]. In such a setting, it is imperative that facilities provide ongoing care for chronic illnesses [25,28,33,53,67,69,95,96,100,101,106,110,112] and mental health support [25,28,33,53,67,69,93–101,113,119,120,124]. They should also provide continuity of time-sensitive essential services, such as contraception and abortion [28,33,67,94,100], testing for sexually transmitted infections [67,94] and selected immunizations [67] and palliative care [67,84]. Furthermore, treating minor infections and injuries during disasters at the PHC level is essential to prevent the overburdening of hospital and emergency services [67,95,101,125]. Many authors (n = 27) point out that a well-prepared PHC system will integrate public health functions into their service offerings [18,25,28,33,44,50,52,54,57,64–67,75,77,82,100,102,110,114,117,121,125–129]. PHC facilities are often the first responders to public health emergencies [125,126] and can function as a multi-hazard early-warning system [28,44,54,64,65]. During infectious disease outbreaks, PHC can offer surveillance and monitoring of new cases [25,28,64,67,77,109,129], and can act to isolate infected individuals so as to prevent transmission [33,100,102,127]. PHC facilities can also contribute to reducing the potential morbidity and mortality of novel infectious diseases through an effective early management of cases [50]. A PHC system can assist public health authorities in several ways on account of its broad geographical reach and the close relationships shared between PHC per-

Table 4
Causes of disruption of care and practical actions to grant continuity of care found in the literature.

Possible cause of disruption of health service delivery	Strategy to grant continuity of operations	Policy Level	Local Level
Affected Health Workers	*Training and capacity building*	Nation-wide education and accreditation system for PHC professionals on disaster medicine (par. 3.2.2.1)	Training of every healthcare worker (par. 3.2.4.3)
	Safety of health care workers	Policies on occupational safety of health care workers (par 3.2.2.1)	Occupational safety for every healthcare worker (par. 3.2.4.4)
	Task shifting	Clear policies and clear profiles of lay workers (par. 3.2.2.1)	Plans for task-shifting to other categories and cross-organizational collaboration (par. 3.2.4.1)
Non-physical inaccessibility (lack of entitlement to healthcare, financial barriers, cultural and linguistic barriers)	*Basic care granted for everyone*	Render basic healthcare accessible to everyone (par. 3.2.2.1)	Lowering barriers to access to care (par. 3.2.2.3)
Direct structural damage of the health facility or physical inaccessibility	*Alternate models of care: home-based care, mobile clinics, distant sites, etc..*	Facilitate implementation of alternate models of care (par 3.2.2.1)	Implement a strategy in case of inaccessibility to infrastructure (par 3.2.3.2)
	Telemedicine	Grant access to telehealth in under-resourced settings and to underserved populations (par. 3.2.2.1)	Train workers and patients to telehealth (par. 3.2.5.2)
	Health information system	Implementation of a timely, regular, and robust country health information system through which health records are protected (par. 3.2.5.2)	Implement a centralized and remotely accessible health information system (par. 3.2.5.2)
Damage of supporting systems: - logistics - communications - power - water supply	*Multidisciplinary strategy for the provision of supplies at the PHC level*	Make an incident management plan involving all services (transport, road communications, electricity, pharmacists, etc.) to maintain critical systems (par 3.2.3.2)	Make sure that the plan to maintain critical system is implemented and shared (par 3.2.3.2)

sonnel and the communities they serve. For example, the PHC system can provide data or samples for clinical, and laboratory-based surveillance, and implement control measures or large-scale population testing and contact-tracing. The PHC system is also capable of triaging and monitoring people in isolation or quarantine. PHC that is integrated with public health can be the most cost-efficient way to prevent the spread of negative health outcomes among high-risk populations [33] and empower communities during a disaster [100].

3.2.2.3. Community engagement. There is evidence in the literature (n = 36) that community disaster preparedness can most effectively be enhanced through the PHC infrastructure [18,21–23,25,28,41,44,51,60,65,75,82,88,90,91,96,97,102,104,109,110,116,117,120,125,129–138]. Trust built in primary healthcare settings was identified as a pivotal factor for community engagement and adherence to protective behaviors [44,129]. A community educational intervention that leveraged the existing PHC infrastructure was effective in enhancing both risk awareness and disaster preparedness among rural and urban regions of Iran [139]. High-quality PHC services were effective in building resilience to the COVID-19 outbreak in Arab communities in Israel [109] and among vulnerable communities in Brazil [51].

Community preparedness strategies should be disseminated through proactive outreach initiatives [18,22,23,25,28,45,53,59,67,86,90,91,102,104,122,134,138,140]. These enhance disaster health risk literacy and preparedness through education and promotion of awareness towards disasters and are a cost-effective approach that bolster communities' resilience [23,25,28,44,54,102,120,122,134,137]]. Engaging in such outreach initiatives is particularly beneficial for high-risk patients such as homebound, bedridden individuals or children with special needs [53,67]. It is recommended that PHC facilities work in collaboration with other community-based services (schools, local departments of health, places of worship, advocacy groups, pharmacies, paramedics, etc.) to boost community resilience [22,27,42,44,45,68,73,88,94,104,136,141]. Community coalitions have proven to be effective in the UK during COVID-19 [44] and among vulnerable groups including children in the US [68,88,104].

PHC is also an established network through which important public health messages are communicated and disseminated to patients in a personalized way, especially to vulnerable communities [28,52,82,142]. During disasters, in fact, primary care teams are a trusted source of information and can contribute to a better adherence to protective behaviors [44]. Patients are, in fact, more likely to be prepared for a disaster if they receive specific instructions from their PHC physician [22,104,143]. Kunin and Desborough provide positive examples of PHC providers acting as sources of reliable health information during the outbreaks of SARS, H1N1 and Ebola [17,73]. This phenomenon is reported in many other articles [25,31,32,44,57,64,70,78,106,114,128,129,141,144,145] It is important that information can reach people with disabilities or other barriers to accessing data (e.g., dissemination of health information in different languages or to people with visual and/or hearing impairment) [82]. Also, public information activities should be coordinated among stakeholders to avoid the dissemination of conflicting information. In this view, a good use of telecommunications technology is recommended as an effective way to ensure ongoing communication between health authorities and the community [67,144].

3.2.2.4. Patient and household preparedness. Closely related to PHC's effectiveness in disseminating information is its ability to bolster individual patient and household preparedness (n = 29). PHC professionals can help patients accurately understand risks, increasing preparedness by involving the patients in the co-management of their health and safety [18,20,22,49,55,60,64,65,67,75,79,88,96,97,102,104,106,110,117,118,120,133–135,138,140,144–146] Clinical encounters should routinely include a discussion of preparedness strategies, especially for at risk patients like homebound individuals or people with psychological distress [60,110,117,145]. PHC providers should advise patients on making emergency evacuation plans [69,79] and emergency go-bags (with supplies of food and water, a battery-powered radio, a flashlight, and emergency medications) [64,69,79,143,146]. Patients undergoing long-term treatment for chronic diseases (e.g., diabetes) should have a stock of their essential medications as well as portable/digital medical history summaries that include data about allergies, medications/doses, and medical contact information [102]. Patients should understand key contraindications of their main medications, how to self-administer treatments (i.e., insulin, antibiotics), and how to use home medical devices. PHC physicians should offer to write prescriptions in bulk so that patients can have at least a month's worth of medication on hand at all times in case of an interruption in supply [49,52,67,69,79,105,145]. Pediatricians should discuss and create preparedness plans for their patients and families, including emergency contact numbers and help them designate a safe meeting point in case individuals are separated during a disaster event, possibly in conjunction with friends/neighbors and other community agencies (e.g. schools, childcare centers) [22,104]. The effectiveness of these strategies will increase when combined with educational literature and community-wide preparedness exercises, especially when coordinated with other agencies (e.g., local health department, law enforcement or the community hospital) [110,137,145].

3.2.3. Health information

3.2.3.1. Vulnerability assessment. The literature (n = 27) highlighted the PHC network's potential to identify, address, and prioritize the needs of marginalized populations, thereby lowering their barriers to access to care in times of disaster [20,28,30,49,55,57,59–62,67,76,79,81,106,109–111,121,124,125,127,132,134–136,140]. Relevant examples of vulnerable populations include individuals: 1) outside of working age [20,24,137,147–149] 2) with physical disabilities [143,147], 3) with chronic comorbidities [51,55,71,147], 4) suffering from mental health problems [53,119,120,145], 5) socially or geographically isolated [27,30,60,61,71,79,105,111,135,136,147], and 6) with limited proficiency in the local language [20,24,81,135,147]. These groups are less likely to have social support during the response phase [55] and are generally less able to care for themselves. They face barriers to taking preparedness measures [79,145] and have the least resilience compared to other groups when faced with service disruptions [81,136,147,148]. Furthermore, such individuals are at increased risk of injury, illness, exacerbations of existing conditions [81,136,147], and death [148]. The ongoing COVID-19 pandemic has shown that these populations have a higher risk of hospitalization and death from the virus and are simultaneously more vulnerable to the pandemic's social, financial, and psychological effects [109]. Assessing vulnerabilities at the PHC level before a disaster strikes, serves to better support these populations in the aftermath of the disaster [19,28,42,55,60,74,77,79,107,108,118,119,135,150,151]. The standard vulnerability markers listed above, and novel vulnerability identifiers (physical or intellectual disability) should be noted in assessments. Assessment results should be integrated into both PHC facilities' health information system (HIS) and community disaster preparedness databases [141]]. After Hurricanes Sandy and Irene hit New York City, PHC facilities collaborated to create a citywide registry of homebound and vulnerable individuals along with an outreach and recovery plan addressing their needs [148].

Assessments should ideally be interdisciplinary, involving medical doctors, nurses, social workers, rehabilitation therapists, pharmacists, nutrition specialists, and psychologists in order to be able to capture all elements that contribute to individuals' vulnerability [140]. Assessments can also be performed outside the PHC premises during proactive outreach sessions performed by lay workers [49] that are able to capture hidden specific needs and barriers of vulnerable individuals. Some tools for preparedness assessment for specific vulnerable populations have already been developed in local contexts in the US for assessing the preparedness of homebound individuals [60]. After the assessment, the goal is to build emergency capability and capacity of these vulnerable categories at the individual and community level [77] to raise awareness and preparedness levels and enable better self-care [96].

3.2.3.2. Incident response plan. Several papers (n = 16) advocate that all PHC facilities should have incident response plans, with clear instructions to follow during response and recovery actions [20,22,24,26,27,30,34,39,42,56,57,67,80,84,145,147] There should be regional/national coordination of plans for all health facilities involved in disaster response to ensure that supply chains are not disrupted in the aftermath of a disaster. Additionally, facilities need evacuation plans in case a disaster hits during working hours [28,32].

Immediately after a disaster occurs, infrastructure and facilities should be subject to rapid needs and damage assessments. If facilities are deemed unsafe or inoperable, plans for using alternative sites should be in place. Back-up plans for electricity, telecommunications, and water/sanitation systems should also be present [32,78]. Clear contingency plans for the provision of supplies, equipment, and medications should be drawn up in advance (e.g., a plan to ensure medication/vaccine storage if electricity fails) [25,28,32,56,59,78,102,106]. Every outpatient medical facility should aim to minimize dependence on external help and maximize self-reliance in case of prolonged outages. Centralized leadership and macro-level coordination with other sectors is necessary to ensure that supply chains are not disrupted during and after a disaster.

It is also vital that PHC facilities perform rapid health-needs assessments throughout the affected community in the aftermath of a disaster [20,22,25,28,32,40,54–56,65,78,82]. Furthermore, clear guidelines should exist on triage procedures that consider pressing clinical needs or vulnerability factors [20,21,30,57,62,76,79,81,109,110,122,124].

3.2.4. Health workforce

3.2.4.1. Multidisciplinary team. The literature (n = 14) asserts that having a multidisciplinary team at PHC facilities is critical for building optimal disaster preparedness strategies [21,39,42,45,53,54,63,68,77,104,118,121,122,152].

A study in the US found that assigning different aspects of the preparedness assessment to different disciplines (nurses, occupational therapists, psychologists) resulted in more detailed and actionable data for helping homebound elderly individuals to be prepared for disasters [118]. There are no standardized guidelines articulating which types of professionals ought to be included in such teams. However, it is generally accepted that the profile of professionals will match the needs of the target populations. So-called family health teams consisting of physicians, nurse practitioners, social workers, pharmacists, and dieticians were deployed in Ontario, Canada in response to the 2009 H1N1 pandemic. This resulted in: 1) increased understanding of the health needs of the population, 2) detailed disease surveillance in affected communities, and 3) high patient and physician satisfaction [52].

The competencies of PHC nurses in DM were emphasized in the literature. One study highlighted nurses' multiple functions in mitigating the impacts of hydrological disasters in rural areas of Brazil [43]. A second study showed that nurses were uniquely positioned to coordinate surge capacity, patient education, and communication between staff and patients [18]. A third paper reported that nurses' duties expanded to include the management of both the palliative care and the deaths of increasing numbers of patients during the COVID-19 pandemic [66].

There is a large body of evidence showing that community health workers (CHWs) can play a critical role in disaster preparedness [22,23,25,41,48,49,53,63,67,82,90,91,97,100,102,119,121,124,149]. Due to their strong relationships with the population, CHWs can act as intermediaries between the community and the primary care services. Including CHWs into health teams has been shown to prevent disruption in health services during disasters in Kerala, India [102] and in Haiti [41]. For countries with limited resources or geographically isolated populations, CHWs may be the only responders available to assist in the period immediately following a disaster. Large-scale CHW programs can even take on many PHC functions, such as: family planning services, disease surveillance, immunization tracking, initial clinical consultations, treatment of mild respiratory infections, health education for patients with chronic conditions [22,97,119,124], as well as education on newborn care, nutrition, proper hygiene, and safe motherhood [22,41,48,67,82,119,149]. CHWs can unburden medical doctors and nurses from less specialized tasks and responsibilities [25,53,90,91,124]. This cadre should be trained on core competencies using standardized curricula and incorporated into the emergency response teams [23,63]. The literature also contained examples of emergency volunteers performing support tasks (health promotion, outreach, preventative measures in chronic disease management) after adequate training [25,53,90,91,124].

3.2.4.2. Surge capacity. Properly utilizing PHC can extend the capacity of hospital and emergency departments during disasters by directly augmenting and supporting crises medical surges according to 12 papers [27,30,34,55,78–80,103,108,110,118,152]. Every PHC facility should adopt a clear strategy for how to maintain staffing to continue operations during a disaster and in its aftermath. An emergency staffing plan that includes workers' specific competencies, contact information, and expected availability should be always kept on hand [20]. The surge capacity for human resources should be coordinated at community, regional, or national levels. Staffing plans should be shared among local PHC providers and among public and private care networks to facilitate mobility of staff, thereby maximizing clinical capacity [67,73].

3.2.4.3. Training and education. Though the need for incorporating preparedness education into national certification for healthcare workers was mentioned with regard to continuity of care, the literature (n = 40) also called for training to take place at the local level in PHC facilities [20,25,27,28,30,32–35,39,42,60,63,64,66–68,75,78–80,83,84,89–91,94,97,103,106,112,116,128,129,149,153–157]. Around the world, health professionals and support staff are still largely unprepared to respond to disasters due to a dearth of training and disaster experience [24,81,92,126]. As a consequence, PHC staff often report feeling unprepared to deal with disasters [30,56,64,72,87,153,158]. It has been speculated that this lack of preparation may be due to a lack of interest on the part of PHC staff, perceptions of low risk for PHC facilities, or the absence of frameworks and systems to prepare these professionals for DM [64,87]. Also, DM-related core competencies and skills for PHC professionals have not been yet standardized [23]. The literature identified four key aspects for training curricula: 1) basic skills and concepts of DM (i.e. role of PHC professionals in emergency plan, office preparedness, human resources management, patient preparedness, mass-casualty incidents) [28,40,81,87,101,114,126,127]; 2) clinical and technical skills (i.e. triage, basic or advanced life support, bleeding control and management of disaster-specific injuries or diseases, counselling and psychological aid) [61,64,65,95,156]; 3) public health emergency skills (i.e. infectious disease outbreaks, infection and prevention control standards, use of personal protective equipment – PPE -, surveillance/early warning, risk communication, coordination with partners, and case management for relevant public health threats) [29,31,33,61,73,78,81,82,126,127] 4) additional skills (teamwork, internal communication, and physical fitness to enable health professionals to work together effectively in disaster settings) [81]. Training programs should be incorporated into ongoing clinical education programs for every PHC professional [73], including nurses [155] and community health workers [33,82,90,91,154]. Training should be prioritized for PHC professionals serving geographically hard-to-reach areas where disaster management procedures can be different and more complex [18,114]. Practical exercises and drills are also useful, as they increase competence and perception of preparedness on disaster medicine [27,66,79,84,106,110,129,149,152,153,157,159–161]. Therefore, it is best to conduct such activities in tandem with the community as explained above [22].

3.2.4.4. Safety and protection of workers. The literature (n = 17) stresses the importance of guaranteeing the safety and protection of all cadres of PHC workers [20,30,34,66,68,74,75,80,83,85,92,93,108,117,118,121,123]. The lesson of the worldwide lack of PPE for healthcare workers during the first stages of the COVID-19

pandemic cannot be overemphasized [83,115,116] Healthcare professionals are more likely to continue working during a disaster if they feel supported and valued by their organization [115]. Monitoring and assisting with the disaster-related psychological impacts on healthcare workers is also necessary [78,116]. PHC facilities can also help alleviate stressors during disaster response by providing child-care and flexible hours for critical staff [117].

3.2.5. Medical products and technologies

3.2.5.1. Appropriate medical and lab equipment and supplies. Several articles (n = 12) note that having proper supplies of medical and laboratory equipment is essential for maintaining operations during a disaster [20,27,30,34,39,61,66,87,104,144,147,161]. Each PHC facility should have an inventoried list of stocked medicines corresponding to the national list of the essential drugs, and a list of supplies and devices (or lab equipment, if applicable) that may be necessary during a disaster. Disaster preparedness principles should also inform how critical supplies are stored [33]. Medicines and supplies can be pre-positioned in areas where they can be easily accessible during a disaster, (e.g., in areas outside of flood risk ahead of the rainy season). Some authors also recommend the readying of emergency health kits or professional go-bags in case operations need to be conducted outside of the PHC facilities [20,30,66]. Go-bags should contain essential medicines and medical devices that are generally used outside of the PHC facilities [20,30].

3.2.5.2. Appropriate infrastructure and technology. The need for having resilient infrastructure and technology was stressed in the literature (n = 8). Having safe and secure PHC facilities will protect the lives of individuals and enable effective health response and recovery [25,32,56,62,65,75,78,161]. There is no internationally recognized method to evaluate the structural safety of PHC centers in case of disasters. The WHO Hospital Safety Index [162] has been used, but a detailed analysis of the index's questions and their relevance for the primary care setting has not been carried out yet [32].

A centralized, robust, remotely accessible HIS is an essential part of any health care facility that aims to maintain continuity of care during disasters [30,34,64,66,80,81,104,106,108,130,161,163]. HIS data should be backed up on a geographically distant server, with records tested periodically for recoverability and completeness [104]. If health records are kept on paper, files should be stored and protected from possible damages [64]. A robust HIS at the PHC level will guarantee secure, confidential, and mobile access to patient medical information. It allows staff to monitor patients with chronic diseases [79,106], prevent the interruption of therapies, and help identify vulnerable categories of individuals. The issuance of unique identification numbers to patients in a HIS has been used as a proxy for indicating a PHC system's disaster resilience [128].

As a long-term disaster response progresses, HIS data from local PHC facilities can be used to obtain an overall picture of health trends. Implementing geographical data/mapping in the HIS could also be beneficial for effective preparedness [56,155,161]. This data may be also used to: 1) assess whether the PHC local network is able to serve the individuals impacted by the disaster, 2) understand shifts in healthcare utilization patterns, 3) monitor health conditions directly or indirectly related to the disaster, and 4) track post-disaster trends in ambulatory care [163].

All health centers should have a fully functional communication system with a backup plan for alternative means of exchanging information (e.g., radio, walkie-talkie) [34,35,61,75,77,98,106,109]. Partnerships between the Ministry of Health and private communication companies were arranged in Sudan and Serbia, which ultimately provided a free of charge communication system to all health facilities, including PHC centers [32,75]. A fast and stable Internet connection should be always present to guarantee the correct functioning of telehealth consultations in the aftermath of a disaster. The ongoing COVID-19 pandemic has shown that access to digital health technology is often problematic for underserved populations and in some low-income countries, making telehealth impractical [33,107]. A robust computer network security system should also be adopted at national and local levels to protect patient records from new emerging cybersecurity hazards [32].

3.2.6. Financing

3.2.6.1. Financial resources. A few articles (n = 11) mention the need to increase funding overall for PHC preparedness. Adequate allocation of financial resources is a critical aspect for preparedness at the PHC level to be able to develop capacities and implement programmes and community-based preparedness activities [33,39,69,75,90,91,163], including education and training for PHC professionals, and to establish community health services [31,67,73,88,161]. It is also important that such a funding is specifically earmarked for PHC facilities. Unfortunately, PHC's role in responding to emergencies has been historically overlooked. Governments should ensure that sufficient money is distributed so that action plans against emergencies are implemented in every health facility involved in DM [161].

4. Discussion

Although the ongoing COVID-19 pandemic has demonstrated the importance of disaster preparedness and the resilience of healthcare systems, this manuscript clearly shows that the literature on PHC disaster preparedness contains many gaps. Few of the studies reviewed had a robust methodological design, pointing to the need for more rigorous research on the subject as highlighted in the H-EDRM Framework. Furthermore, the literature has been primarily focused on HICs, while PHC systems in LAMICs are generally more vulnerable to disasters. Nearly two thirds of the reviewed articles examined preparedness for specific hazards while PHC systems should strive to have an all-hazard approach to preparedness, in line with H-EDRM recommendations. Lastly, there is still a severe paucity of scholarship addressing practical service delivery recommendations for a prepared PHC system to comply with the H-EDRM

Framework precepts. Practical recommendations for PHC facilities on how to integrate multidisciplinary services or patient preparedness strategies are lacking and may represent fruitful topics for further research.

To the best of the authors' knowledge, this is the first review of the literature proposing a framework on the specific assets that contribute to PHC disaster preparedness. This paper lays the groundwork to deliver practical recommendations to assess and improve PHC disaster preparedness.

The present study has some limitations. It is not fully comprehensive because it does not address the role of PHC in preparing individuals and communities for climate change-related and environmental disasters. Few articles were found that focus on this topic which definitely needs more attention in the coming years. There may also be characteristics of PHC preparedness that are not yet published. The global north and HICs dominate academic publishing, a fact that may affect the generalizability of the findings. Future research on the subject, especially from LAMIC, should be encouraged, incorporating qualitative methods to learn what solutions have been implemented by workers in different contexts on the ground.

5. Conclusion

Globally, the PHC system has the potential to help reduce the health effects of disasters, acting across all phases of the DM cycle. This manuscript highlights the most important characteristics that render a PHC system prepared for disasters and lays the groundwork to deliver a set of guidelines for PHC systems to follow in order to assess and then boost their disaster preparedness. The findings may also be used to raise awareness among international policymakers and health practitioners, to design interventions to integrate the PHC system into overall DM strategies and to assess the PHC disaster preparedness in different political, developmental, and cultural contexts.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

Data will be made available on request.

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