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Preparedness, Implications, and Administrative Responses to Public Health Emergencies in Relation to Health Security, Health Informatics, and Health Administration: An Updated Review

Mabkhoot Mohammed Mabkhoot Aldawsari [(1)] , Faris Salem Bin Mohammed Al Habuban [(2)] , Abdulkarim Marzooq Awad Alhejaili [(3)] , Hamed Abdullah Alotaibi [(4)] , Ibrahim Yahia Mohammed Aqeel [(5)] , Sara Suliman Albedah [(6)] , Sultan Khalid Mohammed Orayji [(7)] , Tasneem Saeed Moeeni [(8)] , Mosab Mohammed Sawan [(9)] , Naji Saleh Alshehri [(10)] , Aeshah Bawkaryahyazaylaee [(11)]

(1) Wadi Al-Dawasir General Hospital, Ministery Of Health, Saudi Arabia,
(2) Wadi Al-Dawasir Hospital, Ministery of Health, Saudi Arabia,
(3) King Salman Bin Abdulaziz Medical City, Ministry Of Health, Saudi Arabia,
(4) Dharmah General Hospital,Ministry Of Health, Saudi Arabia,
(5) King Fahd Cinteral Hospital In Gizan,Ministry Of Health, Saudi Arabia,
(6) Ad Diriyah Hospital,Ministry Of Health, Saudi Arabia,
(7) King Fahd Central Hospital Health,Ministry Of Health, Saudi Arabia,
(8) Imam Abdulrahman Al-Faisal Hospital In Riyadh,Ministry Of Health, Saudi Arabia,
(9) Damad General Hospital,Ministry Of Health, Saudi Arabia,
(10) Tabuk Health Cluster,Ministry Of Health, Saudi Arabia,
(11) Damad General Hospital, Jazan, Ministry Of Health, Saudi Arabia

Abstract

Background: Public health emergencies (PHEs)—arising from conflict, displacement, pandemics, and climate-related hazards—disrupt the six health-system building blocks and widen inequities, particularly among women, children, older adults, people with disabilities, and low-income groups. Primary health care (PHC) is pivotal for equitable, rapid, and community-anchored responses.
Aim: To synthesize updated evidence on preparedness, impacts, and administrative responses to PHEs, with emphasis on health security, health informatics, and health administration, and to identify lessons that strengthen PHC-centred resilience.
Methods: A scoping review (PRISMA-ScR) across major databases and grey literature (to Oct 30, 2022) included studies in English without geographic limits. Data were thematically analyzed across the PHE cycle: preparedness, impacts, response, recovery, and learning.
Results: Preparedness gaps were common: workforce shortages, weak stockpiles, fragile infrastructure, unclear SOPs, and limited surveillance/incident command. Nevertheless, decentralized governance, routine simulations, and reorganized PHC improved readiness (e.g., Indonesia, Shenzhen, Japan). PHEs strained service delivery, workforce wellbeing, information systems, financing, and governance, amplifying digital and social inequities. Effective responses integrated PHC with public health, leveraged multisectoral partnerships, deployed multidisciplinary/community health teams, and scaled digital tools (telemedicine, early warning, real-time monitoring).
Conclusion: Building resilient PHC requires integrated governance, sustained financing, interoperable digital health, workforce surge and support, and community engagement to ensure continuity, equity, and health security across future PHEs.
Keywords: Public health emergency; health security; primary health care; preparedness; resilience; digital health; multisectoral collaboration; health administration; health informatics; equity..

Introduction

Health security represents a foundational pillar of public health systems, as it focuses on safeguarding populations from health threats through effective prevention, early detection, and timely response to public health emergencies (PHEs). These emergencies often emerge as a result of catastrophic health events or sudden systemic shocks that disrupt societal stability and overwhelm health system capacities. Such events may originate from human-made causes, including armed conflicts, forced population displacement, and large-scale pandemics, or from natural phenomena linked to biological, geophysical, climatological, and environmental hazards, including those intensified by climate change [1][2][3]. The growing frequency and intensity of these threats underscore the expanding scope of health security beyond traditional disease control to encompass complex social, political, and environmental determinants. Multiple structural and contextual factors contribute to the magnitude and complexity of PHEs. Political instability and

prolonged unrest often precipitate armed conflicts and humanitarian crises, which in turn generate unmanaged displaced and refugee populations with limited access to essential health services. These conditions amplify vulnerability to infectious disease outbreaks and hinder coordinated emergency responses. Simultaneously, environmental degradation associated with global warming and climate change has accelerated the emergence and re-emergence of infectious diseases while facilitating the spread of drug-resistant pathogens [4]. Changes in temperature, rainfall patterns, and ecosystem balance have altered disease vectors and transmission dynamics, placing additional strain on already fragile health systems. Natural disasters further compound these challenges by damaging essential public health infrastructure, including water supply, sanitation facilities, and waste management systems, thereby increasing disease risk and generating surges in healthcare demand that exceed system capacity [5][6].

Public health emergencies exert direct and profound effects across all six core health system building blocks, namely service delivery, medical products and technologies, the health workforce, governance structures, health information systems, and financing mechanisms [7]. Disruptions in any of these components can compromise system functionality and reduce the ability to deliver timely and equitable care. A common immediate consequence of PHEs is the interruption of routine health services, resulting in reduced access to preventive, curative, and rehabilitative care [8]. These disruptions may persist long after the acute phase of an emergency, contributing to excess morbidity and mortality unrelated to the original event. Beyond the health sector, PHEs generate substantial indirect impacts on other critical sectors, including transportation, food systems, and supply chains. Damage to road networks and essential infrastructure can obstruct the movement of patients, health workers, and medical supplies, while shortages of food and essential commodities further exacerbate population vulnerability [9]. The adverse effects of PHEs are not distributed evenly across populations. Priority and at-risk groups, including women, children, older adults, individuals living with disabilities, and those of lower socioeconomic status, are disproportionately exposed to the consequences of emergencies and often experience heightened vulnerability and marginalization [10]. These populations face greater barriers to accessing care and social protection during crises, increasing their risk of adverse health and social outcomes. The COVID-19 pandemic provided a recent and illustrative example of these inequities, as priority populations experienced both direct health impacts, such as higher infection rates and disease severity, and indirect effects, including economic insecurity, employment loss, reduced working hours, and the social consequences of prolonged lockdown measures [11].

In this context, the primary health care (PHC) approach has been widely recognized as a critical framework for early and effective responses to PHEs. PHC emphasizes multisectoral collaboration, equity, and the protection of human dignity and rights, making it particularly suited to addressing the complex and interconnected challenges posed by emergencies [12]. Community-based PHC systems can deliver comprehensive, affordable, and culturally acceptable services at the first point of contact, thereby strengthening early detection, risk communication, and continuity of care during PHEs [13][14]. Effective emergency responses further depend on the development of interdisciplinary teams, the design of integrated and context-specific interventions, and sustained collaboration with civil society organizations and local communities [15][16]. Health system preparedness, including early warning, alert mechanisms, and coordinated response planning, is essential to mitigate the immediate and long-term impacts of PHEs [17]. Moreover, systematic review and synthesis of lessons learned from previous emergencies play a vital role in strengthening future preparedness and response capacities. This scoping review therefore sought to synthesize existing evidence on the impacts of PHEs, and the lessons derived from response efforts, with the aim of informing stakeholders and supporting the development of strategies that enhance health system resilience and health security.

Methods

This study employed a scoping review design to map and synthesize published evidence on health security and primary health care utilization during public health emergencies. The review was conducted in accordance with the PRISMA extension for scoping reviews guidelines [18] and was guided by the methodological framework developed by Arksey and O'Malley, with subsequent refinements by Levac et al. [19]. The framework structured the review process through the identification of research questions, systematic searching, study selection, data extraction, and synthesis of findings. The review was guided by three key questions addressing health system preparedness, the impacts of public health emergencies on health systems and services, and health system responses and lessons learned. These questions were operationalized using the population, concept, and context framework proposed by the JBI [20]. A comprehensive search was conducted across eight major electronic databases and relevant grey literature, complemented by reference list screening. Searches focused on health security and primary health care concepts, with studies published in English up to 30 October 2022 included without geographical restriction. Eligible studies of all designs were included based on relevance to the research questions

rather than methodological quality. Data extraction captured study characteristics and key findings and was independently verified. The synthesis applied inductive thematic analysis [23], structured around stages of the public health emergency cycle, namely preparedness, impacts, and responses, including recovery and learning [11][24]. The review relied exclusively on secondary data and did not involve patient or public participation, negating the need for ethical approval.

Preparedness

Preparedness constitutes a central pillar of health security, as effective preplanning, continuous monitoring, and robust surveillance systems are essential to reduce the scale and severity of public health emergencies (PHEs). Across diverse contexts, evidence demonstrates that preparedness is not a static capacity but a dynamic process shaped by governance structures, system resilience, and the ability to translate plans into operational action. Many health systems, particularly those operating under resource constraints or fragile political conditions, have faced persistent challenges that undermine their readiness to anticipate, detect, and respond to health shocks. A recurring theme across settings is the structural weakness of preparedness mechanisms. Health systems have frequently reported shortages of trained personnel, essential medical supplies, and emergency stockpiles, alongside inadequate facilities designed to manage large-scale emergencies [31][32][33][34][35][36]. These limitations are often compounded by the absence of reliable electricity backup, weak infrastructure, and the lack of clear standard operating procedures and emergency policies, all of which impede coordinated responses during crises [31][32][33][34][35][36]. Inefficient transportation systems, poor communication networks, and underdeveloped incident command structures further restrict timely response and coordination, particularly in geographically dispersed or conflict-affected regions [33][34][35][36]. The experience of Cameroon illustrates how fragile primary health care (PHC) systems, coupled with insufficient preparedness for PHEs, constrained response capacity and delayed recovery efforts during and after the COVID-19 pandemic [37].

In contexts characterized by armed conflict and recurrent disasters, preparedness gaps are often intensified by deeper systemic challenges. Deficiencies in governance, financing arrangements, workforce availability, accountability mechanisms, and service coordination have significantly affected the implementation of PHC during emergencies [13]. These gaps limit the capacity of health systems to maintain continuity of essential services while simultaneously responding to acute shocks. In natural disaster settings, preparedness has also been undermined by limited understanding of the PHC approach among stakeholders in both health and non-health sectors, as well as by siloed operational models within the health sector that restrict integrated disease management and multisectoral collaboration [16][38]. Moreover, insufficient planning, unclear delineation of professional roles, and weak alignment between interventions and population needs have constrained PHC service delivery during the COVID-19 pandemic in many countries, exposing the consequences of fragmented preparedness strategies [39]. Despite these challenges, several contexts provide evidence of effective preparedness and surveillance practices that strengthened health system responses to PHEs. In Indonesia, decentralized health system governance and targeted system strengthening initiatives, including national action plans for health security and structured preparedness planning, contributed to enhanced emergency readiness [25]. These efforts were operationalized through the enforcement of mandatory minimum service standards at the local level, alignment with national disaster management systems, decentralized contingency planning, and the routine use of simulation exercises to test readiness for potential future emergencies. Such measures facilitated more adaptive and context-sensitive responses, demonstrating the value of decentralization when supported by coherent national frameworks.

Similarly, the experience of Shenzhen in China highlighted the importance of coordinated preparedness across health care systems. The city's structured approach to preparedness planning and inter-institutional coordination enabled the strengthening of response capacities, providing a model that informed preparedness strategies in other urban settings facing similar risks [26]. In Japan, daily post-disaster disease surveillance reporting played a critical role in tailoring responses to local epidemiological patterns, facilitating the establishment of support networks, and enabling the efficient integration of available resources [27]. These surveillance mechanisms enhanced situational awareness and supported evidence-informed decision making. In addition, proactive reorganization of PHC services in several settings contributed to improved pandemic preparedness, strengthened surveillance capacities, and more effective responses to future health system shocks [28][29][30]. Collectively, these examples underscore the role of adaptive governance, timely data, and PHC-centred planning in advancing preparedness. Public health emergencies generate wide-ranging impacts that extend beyond immediate health outcomes, affecting social structures, service delivery, and equity. PHEs produce both direct impacts, such as disruptions to supply chains and interruptions in health service delivery, and indirect impacts, including damage to infrastructure, road networks, and communication systems. These disruptions often exacerbate pre-existing structural inequities and deepen disparities in access to care. One of the most prominent consequences of PHEs is the sharp increase in health needs, particularly in settings affected by armed conflict and mass displacement.

Armed conflicts have led to substantial increases in the number of internally displaced persons and refugees, resulting in overcrowded living conditions and placing extreme pressure on already constrained health systems. In the Democratic Republic of the Congo (DRC), for example, prolonged conflict contributed to a surge in Ebola cases, overwhelming health services and amplifying demand for care beyond system capacity [33]. Displaced populations frequently require comprehensive health services, including communicable disease control, maternal and child health care, and mental health support, which intensifies the burden on host health systems and complicates PHC implementation.

In PHE contexts shaped by armed conflict, PHC delivery has been hindered by chronic under-preparedness and limited shock absorption capacity within the public sector [31][32]. Health systems have struggled to sustain service provision, adapt to rapidly changing conditions, and restructure damaged facilities. Limited resilience to conflict-related disruptions and difficulties in rebuilding community trust in public institutions have further undermined PHC effectiveness [31][32]. Both displaced and host populations in conflict-affected settings have experienced reduced access to public health services and heightened exposure to infectious diseases and mental health disorders [33][40]. Inadequate access to hygiene and sanitation, including safe water, alongside restricted access to PHC services, has amplified vulnerability among affected communities [33][40]. Country-specific experiences further illustrate these impacts. In Libya, armed conflict resulted in extensive structural damage to health facilities, shortages of medical supplies, threats to the safety of PHC staff, and breakdowns in communication systems. These factors contributed to increased numbers of neglected and orphaned children and the emergence of unusual infectious diseases [41]. In the DRC, despite a marked rise in mental health needs associated with prolonged conflict, integrated community mental health services remained largely unavailable, highlighting persistent gaps in PHC delivery during emergencies [33]. In Yemen, ongoing conflict precipitated recurrent cholera outbreaks, placing additional strain on a fragile health system already struggling to meet population needs [42]. Conflict-affected regions during the Ebola epidemic in Guinea, Sierra Leone, and Liberia provide further evidence of how PHEs can destabilize health systems. In these contexts, health system fragility intensified, leading to deterioration in essential public services for both displaced and host populations [43]. Armed conflicts also disrupted care accessibility by interrupting supply chain management and undermining short-term health programmes [42][44]. Key factors constraining health care delivery included weak community health integration, restricted mobility, poor supervision and monitoring, threats to health workers, limited supply chain

capacity, politicization of humanitarian aid, and rising costs of care [42][44]. Civil instability and natural disasters additionally prompted individuals to delay or abandon routine health care, including mental health services, further compounding the long-term impacts of PHEs on population health [33][45].

Constraints of Service Delivery

Health service delivery during public health emergencies (PHEs) is frequently constrained by systemic, infrastructural, and operational challenges that undermine the ability of primary health care (PHC) to meet population needs. Across diverse contexts, PHEs expose weaknesses in workforce capacity, facility preparedness, resource allocation, and coordination, all of which directly impact service continuity, quality, and accessibility. Workforce limitations represent a critical barrier in many health systems. In Australia, for example, a shortage of trained PHC personnel in remote regions increased the risk of COVID-19 transmission, illustrating the direct link between workforce preparedness and infection control [46]. Similarly, in Lombardy, Italy, a lack of coordinated support in PHC services shifted the burden to hospitals, resulting in overcrowding and elevated risk of nosocomial infections [47]. In Brazil, disruption of PHC systems led to inadequate preventive and outbreak control services, leaving populations without essential first-line care [48]. In Malawi, interruptions to key health services reduced facility attendance, as hospitals were prioritized over primary care, leaving PHC facilities ill-equipped to protect staff and patients while delivering essential services [45][48][51]. These examples highlight the compounding effect of workforce shortages, inadequate infrastructure, and poor coordination in limiting the efficacy of PHC during crises. PHEs also reshape the roles, responsibilities, and working conditions of health personnel. Task shifting, altered scopes of practice, financial constraints, and daily uncertainties imposed by emergencies contribute to occupational stress and hinder service delivery [49][50]. Neglected or postponed essential care, weak gatekeeping, limited capacity, and insufficient integration between medical and public health services further compromise patient care [49][50]. In Sub-Saharan Africa, the dual burden of communicable and non-communicable diseases amplifies the impact of PHEs, with health systems unable to adequately address chronic conditions while responding to acute outbreaks, resulting in increased morbidity and mortality [15].

Systemic and infrastructural constraints also impede service delivery. Regions such as Cameroon and the Central African Republic experienced emergency outbreak "hot spots" with limited PHC coverage, creating blind spots in outbreak response and early intervention [28][37]. In Ecuador, new epidemic outbreaks were exacerbated by insufficient preparation, incomplete health indicator data, resource

shortages, weak PHC services, and rising prevalence of pre-existing conditions [34]. During the COVID-19 pandemic, even health systems with comparatively comprehensive service capacity faced challenges in adapting to rapidly shifting resource demands and population behaviours, such as inconsistent adherence to preventive measures, which further strained service delivery [45,51]. Political, financial, and governance constraints also significantly influence PHC functionality. Disputes over resource allocation and underfunding of PHC systems hindered the implementation of infection control measures and compromised the capacity of primary care facilities to address population health needs effectively [28][37]. The Ebola outbreaks in Guinea, Sierra Leone, and Liberia provide a salient example, where conflicts and fragile governance weakened primary care systems, facilitating rapid disease transmission and overwhelming existing health infrastructure [43]. Overall, the constraints of service delivery during PHEs reflect the interconnectedness of workforce preparedness, facility infrastructure, coordination mechanisms, and systemic resilience. Weaknesses in any of these domains amplify the impact of emergencies on population health, underscoring the necessity of strengthening PHC systems, investing in health workforce capacity, ensuring operational readiness, and integrating health services across levels of care. Such measures are critical to mitigating the immediate and long-term effects of PHEs while maintaining the continuity of essential services and enhancing health system resilience.

Multiple Impacts on Building Blocks

Public health emergencies (PHEs), and notably the COVID-19 pandemic, have exposed vulnerabilities across all health system building blocks, highlighting gaps in preparedness, resilience, and capacity to maintain essential services. The consequences have been multifaceted, affecting infrastructure, workforce, service delivery, governance, information systems, and financing, and have disproportionately impacted marginalized populations, amplifying existing inequities. Firstly, health facility readiness emerged as a significant challenge. Across numerous contexts, health systems lacked essential material resources, including hand hygiene products, personal protective equipment, diagnostic materials, and necessary medical equipment. Many facilities faced shortages of trained staff, inadequate spaces to ensure physical distancing, and insufficient infrastructure to respond to surges in patient demand [47][51][52]. In some regions, procurement delays, lack of contingency plans, and weak integration of PHC with emergency management further hindered the provision of essential services. Neglect of PHC systems was particularly evident, with hospitals absorbing the majority of cases, creating bottlenecks and compromising preventive care and routine services. Poor case management and inadequate enforcement of

infection control measures amplified both direct and indirect impacts of PHEs, demonstrating the centrality of facility preparedness in health system resilience [47][51][52]. Secondly, service delivery across PHC networks was severely disrupted. Lockdowns, travel restrictions, and the suspension of routine services limited access to care, particularly in remote and underserved regions such as parts of Australia, Sub-Saharan Africa, and South Africa [53][54][55][56][57][58]. Traditional service delivery models struggled to adapt to rapidly evolving emergencies, and in many cases, collateral damage from these disruptions contributed to secondary public health crises. Following natural disasters, damaged infrastructure further intensified the risk of disease outbreaks, as observed in Ecuador and Ebola-affected regions of Africa, where interruptions in health service continuity facilitated the rapid spread of infections [33][34]. These disruptions underscored the interdependence between PHC services, emergency response mechanisms, and broader health system functionality.

The health workforce represented a third critical domain impacted by PHEs. Shortages of clinical staff, particularly nurses and junior doctors, combined with heavy workloads, fatigue, occupational stress, fear of infection, stigma, and grief, undermined service delivery and operational continuity [33][34][47][50][51][55][56][57][58]. In Australia, reliance on fly-in, fly-out or drive-in/drive-out health workers to serve remote populations exemplified both the flexibility and fragility of workforce responses [46]. The pandemic highlighted the necessity of workforce surge capacity, psychological support systems, and adaptive training to maintain service quality during prolonged emergencies. Task-shifting and role adaptation, while necessary in crisis contexts, further contributed to stress and potential gaps in care quality. Information systems and digital infrastructure were also critically affected. Poor digital interoperability, limited access to remote consulting tools, high data and airtime costs, and insufficient training of professionals constrained the use of telehealth and remote monitoring systems [16][27][60][61]. Inadequate data quality, delays in reporting, and gaps in health information management complicated real-time decision-making and undermined the effectiveness of field hospitals and emergency interventions [52][56]. These challenges revealed systemic vulnerabilities in modern health systems' reliance on digital tools and emphasized the importance of robust, interoperable, and equitable health information infrastructure in crisis contexts. Governance and financing limitations further exacerbated PHE impacts. Market-oriented health systems, common in many countries, struggled to prioritize PHC and community engagement during pandemics [62]. In South Africa, weak partnerships between health authorities and communities, coupled with underinvestment in PHC from the private sector,

undermined the reach and effectiveness of the COVID-19 response [56]. Chronic underinvestment, poor coordination of funding and planning, inflexible billing and record-keeping systems, and limited community awareness compounded governance failures [44][60]. Corruption in procurement processes and disincentives for private sector participation in emergency responses threatened the sustainability of service delivery and constrained health system capacity [43][60]. These structural weaknesses impede the realization of universal health coverage (UHC) and leave populations vulnerable during emergencies.

PHEs also amplified health inequities. Unequal distribution of social determinants, including education, income, and geographic accessibility, disproportionately affected marginalized populations, widening pre-existing equity gaps [31][39][62][64]. Structural disparities were exacerbated by the digital divide, where populations without reliable internet or digital devices were excluded from telehealth services and health education initiatives [39][62]. In addition, unpreparedness of healthcare professionals in using digital platforms and insufficient coordination between remote and in-person service delivery further increased inequities throughout the COVID-19 pandemic [39]. Neoliberal governance and market-driven health systems often failed to prioritize equitable access, resulting in structural inequities that challenge the broader goals of UHC [12][62]. Collectively, these multidimensional impacts illustrate how PHEs interact with systemic vulnerabilities to weaken health system performance. Facility deficiencies, disrupted service delivery, workforce stress, limited digital capacity, governance and financing constraints, and structural inequities create cascading effects that compromise population health outcomes. Lessons from COVID-19 and other PHEs demonstrate the need for comprehensive, integrated health system strengthening that addresses infrastructure, workforce capacity, governance, digital health, and equity simultaneously. Investing in resilient PHC systems, enhancing data and digital infrastructure, fostering community engagement, and improving governance mechanisms are critical for mitigating the direct and indirect consequences of emergencies and for ensuring equitable health service delivery under crisis conditions. Strengthening these building blocks not only improves immediate emergency responses but also contributes to long-term health system resilience, the sustainability of UHC, and the capacity to manage future health threats effectively. In conclusion, PHEs reveal the systemic vulnerabilities and interdependencies of health system building blocks. The COVID-19 pandemic exemplifies the compounded effects of inadequate facility readiness, service disruptions, workforce challenges, digital barriers, governance deficits, and inequities on population health outcomes. Addressing these challenges requires integrated strategies that reinforce each building block while prioritizing equity, preparedness, and adaptive capacity. Without such systemic strengthening, health systems remain ill-equipped to manage future emergencies, and the structural inequities exacerbated by PHEs will persist, undermining both health security and broader societal well-being.

Response to Impacts of PHEs

Responding to public health emergencies (PHEs) requires a comprehensive, multisectoral, and coordinated approach. Lessons from recent PHEs, particularly the COVID-19 pandemic, highlight key strategies that can strengthen health system resilience, including preparation, integration of primary health care (PHC) with public health functions, multisectoral collaboration, use of digital tools, effective communication and partnerships, deployment of multidisciplinary health teams, and proactive planning for resilient health systems.

Integrated Public Health and Primary Care

Integration of PHC and public health functions emerged as a fundamental strategy in effective PHE response. Linking the PHC approach with social determinants of health enabled targeted, equitable, and context-specific interventions. Investments in public health infrastructure, reorganization of PHC services, and targeted training of frontline providers enhanced system capacity to manage emergent health needs [28][48][51]. Coordinated public health and PHC activities facilitated the realization of PHC values, including prevention, protection, promotion, and treatment, while improving social and economic indicators in communities [65][66]. Evidence from the pandemic demonstrated that health systems leveraging integrated PHC and public health were better able to maintain service continuity and meet cumulative community needs [45][58][67]. In Sub-Saharan Africa, community-oriented PHC approaches demonstrated long-term benefits, including better equity and access to care and efficient use of technological innovations for service delivery [55]. Strategies included screening and testing, community-based activities, maintenance of essential services, care for vulnerable populations, digital health applications, and empowerment of PHC institutions [29][55][69]. In disaster-prone areas, such as flood-affected regions, facility-specific preparedness plans with defined chains of command and standard operating procedures facilitated rapid response and optimized coordination across PHC facilities [36].

Multisectoral Actions for Impact Responses

Multisectoral collaboration is essential to address complex PHE impacts. Coordination among policymakers, civil society, NGOs, community organizations, and the private sector enabled equitable financing models and strengthened governance frameworks [13]. Engaging communities in planning

and decision-making enhanced trust, satisfaction, and resilience while improving access to services. Israel, for example, demonstrated that suburban communities benefited from collaborative approaches during COVID-19, improving confidence and engagement in local health systems [16][30]. In Cuba, multisectoral coordination significantly mitigated pandemic impacts by aligning public health, PHC, and social support mechanisms [54]. Empowering local agencies and community structures enhances preparedness and response capacity. Social networks, community collaborations, and PHC engagement in minority communities strengthened local surveillance, health education, and service delivery during emergencies [30][70]. In South Africa, multisectoral actions at the provincial level addressed systemic fragilities, protecting both lives and the economy during the COVID-19 crisis [56]. Integrating "One Health" approaches and reinforcing PHC institutions further enhanced readiness for public health threats, aligning with Sustainable Development Goals emphasizing multisectoral coordination, knowledge exchange, and resilient health systems [29][63][71][72]. Coordination and communication between stakeholders and strategic partnerships are critical for effective PHE responses. International collaborations supported procurement, supply chain management, and deployment of medical resources during the Ebola outbreak in West Africa [43][73][74]. Strengthening human and technical resources, alert systems, and evacuation protocols prevented overcrowding in hospitals and protected patients and providers during COVID-19 and natural disasters [27][47][67]. Humanitarian funding and technical assistance reduced opportunity costs and mitigated the severity of emergencies [43][74]. Situation mapping, including demographic analysis, disease transmission patterns, and health system capacity assessments, guided deployment of mobile clinics and outreach services [31][42][68]. Displaced populations in conflict-affected regions, such as Yemen, faced elevated health risks, and partnerships facilitated PHC service delivery, risk communication, and continuity of care [40]. Regional forums and multilateral collaborations enabled cross-country knowledge exchange, pooled procurement, and strategic planning for future emergencies, reinforcing the role of global partnerships in health system resilience [26][71][72][75].

Use of Digital Tools

Digital technologies emerged as an effective tool in PHE response. Telemedicine, e-health platforms, virtual consultations, and digital communication increased service coverage, improved access to care, and facilitated monitoring in remote areas [26][45][49][50][76]. In Dubai, telemedicine services increased by 86% during COVID-19, demonstrating the efficiency and scalability of digital interventions [50]. Digital tools supported health workforce training, patient education, and behaviour change interventions, particularly in rural and underserved communities [60][76]. In Yemen, mobile technology enabled data collection, supervision, risk communication, and pre-positioning of supplies in communities affected by conflict [44]. Early warning systems, real-time monitoring, and digital platforms for disaster preparedness strengthened PHC service delivery and ensured timely interventions [50][77][78]. Integration of digital tools also supported multidisciplinary care coordination and improved continuity of essential services, ensuring equitable access for vulnerable populations [50][77][78][79]. Deployment of multidisciplinary teams strengthened service delivery in conflict and emergency contexts. Community health workers played critical roles in medication delivery, disease surveillance, and chronic disease management [44,55]. Integrated family health teams in China operated flu assessment centers, provided infection control information, and coordinated antiviral treatment, demonstrating effective interdisciplinary response [67]. In Thailand, village health volunteers monitored returnees during COVID-19, enabling containment without nationwide lockdowns [81]. Mobile clinics in Yemen delivered urgent services for children, cholera control, and malnutrition management in epidemic contexts [42]. Shenzhen, China, exemplified community-based PHC integration for surveillance and containment of COVID-19 [26]. These models highlight the importance of workforce training, psychosocial support, and flexible task allocation to ensure resilient and adaptive PHC services [51][56][82].

Planning for Resilient Health Systems

Proactive planning and organizational capacity are essential for resilient responses. Preparedness activities, including disease surveillance, contact tracing, and resource management, optimizing limited resources and mitigate barriers to quality care [52,57,58]. Conflict-affected settings require context-specific strategies, community engagement, and non-health sector collaboration to strengthen PHC infrastructure and ensure equitable service delivery [83]. In Liberia, standardized community health programs with incentivized health assistants improved system readiness for future shocks [69]. Decentralization facilitated reorganization and enhanced emergency response capabilities, as demonstrated in China, where integrated health care strategies strengthened PHC delivery and emergency preparedness [26]. Cuba adopted intersectoral government plans, combining research, universal prevention protocols, and case tracing for effective pandemic response [54]. Iraq implemented resilience strategies including absorption, adaptation, restriction, and transformation in conflict-affected governorates [32]. Nepal established national coordination centers for rapid PHE response, aligning contingency planning, bioethical considerations, data use, and

communication systems [82]. Monitoring and early warning systems are critical to detect PHE hotspots and identify gaps in PHC coverage. Real-time data collection, workforce involvement, and preparedness exercises ensure timely detection, minimize unnecessary contact, and enhance community-level responsiveness [43][66][84]. Such approaches strengthen PHC, reinforce health system building blocks, and improve population health outcomes during emergencies. In conclusion, effective response to PHEs requires integrating PHC with public health, leveraging multisectoral coordination, employing digital tools, deploying multidisciplinary teams, and planning for resilient health systems. Evidence from global PHEs demonstrates that these strategies enhance service delivery, maintain essential care, strengthen system adaptability, and mitigate inequities, providing a foundation for resilient health systems capable of addressing future health emergencies.

Discussion:

This study synthesized evidence on preparedness, impacts, and responses to public health emergencies (PHEs), focusing on armed conflicts, disasters, and infectious disease outbreaks. PHEs strain health systems by increasing health needs, disrupting service delivery, affecting health system building blocks, and exacerbating health inequities. Most evidence comes from low- and middle-income countries (LMICs) with weak preparedness and response mechanisms. Effective PHE responses emphasize integrated public health and primary care (PHC), multisectoral actions, digital tools, multidisciplinary health providers, communication and partnerships, and resilient health system planning. Immediate response requires identification of hotspots, rapid deployment of PHC services, and assessment of local population needs, health system readiness, and short- and long-term service impacts. Community health workers (CHWs) are crucial for implementing PHC, particularly in culturally competent and community-oriented ways. Multidisciplinary teams help identify vulnerable populations, provide outreach, and maintain continuity of care. Partnerships with local organizations, NGOs, and private sector stakeholders strengthen response capacity, support innovative solutions, and ensure equitable service provision. Integration of mental health services post-PHE is also critical. Digital health tools, including telehealth, virtual consultations, and mobile technologies, have enhanced service delivery, access, and workforce training during PHEs. These tools enable monitoring, risk communication, and service continuity, particularly in remote areas. Evidence from COVID-19 highlights that adaptive digital strategies can support emergency planning, resource allocation, and integration of PHC into crisis management systems.

Multisectoral actions address collateral impacts of PHEs, such as disrupted sanitation, transport, and supply chains. Short-term strategies focus on local resource mobilization, emergency coordination, and outreach service delivery, while long-term strategies aim to reduce post-PHE risks, including non-communicable diseases, malnutrition, and mental health disorders. Preparedness and surveillance systems are essential for future PHEs, including workforce training, early warning systems, and national monitoring. Policy and research implications highlight the need to address both acute and chronic PHEs, including economic recessions, famine, and silent health security threats. Global health governance, resource coordination, and multisectoral collaboration are key to reducing inequities and improving resilient PHC systems. This review, following scoping review methodology, synthesized evidence from multiple study designs but was limited by language and the lack of quality appraisal. Future research should examine broader catastrophic events impacting public health.

Conclusion:

This review shows that PHEs expose—and often compound—systemic weaknesses across facilities, services, workforce, information, governance, and financing, with the greatest harms borne by already-marginalized populations. Where preparedness was proactive—through decentralized governance, routine simulations, interoperable surveillance, and PHC reorganization—systems responded faster and more equitably. The most effective responses consistently integrated PHC and public health functions, partnered across sectors and communities, protected and expanded the health workforce (including community health workers), and operationalized digital tools for triage, continuity, and real-time decision-making. Moving from crisis reaction to sustained resilience demands stable PHC financing; clear SOPs and incident command; robust supply chains; data standards and interoperability; mental-health integration; and inclusive community engagement that builds trust. Administratively, aligning incentives, accountability, and cross-sector coordination is essential to mitigate collateral impacts on transport, sanitation, and supply systems. Investing in these capabilities now will strengthen health security, safeguard continuity of essential care, and reduce inequities in future emergencies.

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