



# Health Security in the Face of Climate Change: Strategies for Managing the Complex Interplay of Environmental Challenges and Public Health Emergencies

<sup>1</sup>-Hamed Tarqi Alanazi,<sup>2</sup>- Omad Naif Aldhafeeri,<sup>3</sup>- Ahmed Asi Alshammari,<sup>4</sup>-Faisal Asi H. Alshammari,<sup>5</sup>-Mashari Saad D. Alshammari,<sup>6</sup>- Salamah Falah Aljameeli,<sup>7</sup>-  
Majed Hussain M. Alanazi,<sup>8</sup>- Abdullah Ali Mesfer Alharbi

<sup>1</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster King Khalid General Hospital In Hafar Al-Batin

<sup>2</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster King Khalid General Hospital In Hafar Al-Batin

<sup>3</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster King Khalid General Hospital In Hafar Al-Batin

<sup>4</sup> Ksa, Ministry Of Health, Eradah And Mintal Hospital Hafr Al Batin

<sup>5</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster

<sup>6</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster King Khalid General Hospital In Hafar Al-Batin

<sup>7</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster King Khalid General Hospital In Hafar Al-Batin

<sup>8</sup> Ksa, Ministry Of Health, Hafar Al-Batin Health Cluster King Khalid General Hospital In Hafar Al-Batin

## Abstract

**Background:** Health security is increasingly challenged by climate change and public health emergencies (PHEs), which can arise from both anthropogenic and natural disasters. These crises threaten health systems, particularly in vulnerable populations, exacerbating health disparities and complicating emergency responses.

**Methods:** This study conducted a scoping review of literature from eight electronic databases (PubMed, Scopus, EMBASE, CINAHL, Cochrane, Web of Science, PsycINFO, and Google Scholar) and grey literature, focusing on health security and primary health care (PHC). The review analyzed the implications and lessons learned from various PHEs, including pandemics, armed conflicts, and natural disasters.

**Results:** Findings indicate that PHEs disrupt essential health services and infrastructure, leading to increased morbidity and mortality, particularly among marginalized groups such as women, children, and the elderly. Key challenges identified include inadequate preparedness, resource shortages, and ineffective governance. Successful responses were observed in regions that implemented multisectoral collaboration and integrated PHC strategies, enhancing resilience and health system responsiveness.

**Conclusion:** Addressing the intersection of health security and climate change requires robust preparedness frameworks and multisectoral approaches to mitigate the impacts of PHEs. Stakeholders must prioritize investments in health systems and community engagement to foster resilience and improve health outcomes amid ongoing environmental challenges.

**Keywords:** health security, climate change, public health emergencies, primary health care, resilience.

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## 1. Introduction

Health security safeguards against health risks by avoiding, identifying, and reacting to public health emergencies (PHEs) resulting from catastrophic health occurrences or acute shocks. Catastrophic events may be anthropogenic (e.g., armed wars, forced migrations, and pandemics) or natural catastrophes resulting from biological, geophysical, and climatological hazards, as well as environmental factors (e.g., effects of climate change) [1-3]. Multiple underlying reasons, including as political turmoil, instability resulting in wars, and unregulated displaced people, exacerbate the magnitude and intricacy of PHEs.

Moreover, environmental degradation linked to climate change and global warming incites new and re-emerging illnesses and may foster drug-resistant organisms [4]. Natural disasters may impair public health infrastructures, including water, sanitation, and waste management systems, leading to heightened health service demands and overwhelmed healthcare systems [5, 6].

Public health crises may immediately affect all six components of health system infrastructure: service delivery, medicinal commodities, health personnel, governance, information systems, and funding [7]. The immediate effects of PHEs include the disruption of access to and provision of health care [8]. Conversely, collateral effects of public health emergencies on non-health sectors include damage to transportation networks and infrastructure, scarcity of food and other vital resources, and disruption of supply chain systems [9]. Priority populations—women, children, those with disabilities, the elderly, and those of low socioeconomic status—are more susceptible to the repercussions of events, which may result in further marginalization [10]. The recent COVID-19 pandemic affected these priority groups both directly (e.g., heightened infections) and indirectly (e.g., consequences of lockdowns, job loss, or decreased working hours) [11].

The primary health care (PHC) model is the best appropriate for prompt intervention in public health emergencies (PHEs). The PHC strategy integrates multisectoral policies and activities while emphasizing human dignity and rights [12]. Community-based primary health care systems may provide comprehensive, economical, and acceptable health treatments at the first point of contact in public health emergency scenarios [13, 14]. Responses to public health emergencies may be assured by the formation of multidisciplinary teams, the creation of comprehensive solutions, and collaboration with civil organizations and communities [15, 16]. Ensuring the preparation of health systems, particularly the initiation and notification processes, is essential to lessen the effects of public health emergencies (PHEs) [17-20]. Furthermore, analyzing and integrating insights gained from previous occurrences has been crucial in addressing future public health emergencies [21-26]. This scoping study sought to consolidate existing research about the implications and lessons learnt from responses in public health emergencies. The results may guide stakeholders in identifying viable methods for addressing and minimizing the impacts of public health emergencies while enhancing resilience in health systems.

## **2. Methodology**

We examined eight electronic databases (PubMed, Scopus, EMBASE, CINAHL, Cochrane, Web of Science, PsycINFO, and Google Scholar) and grey literature for papers pertaining to health security and primary health care (PHC). This was followed by supplementary reference searches of included studies and Google searches to locate suitable studies that were not retrieved from the databases.

## **3. Readiness and monitoring**

Health systems have encountered several problems in catastrophe planning. The issues included a deficiency of personnel and resources, inadequate emergency preparedness facilities, absence of electrical backup, and the lack of standard operating procedures and policies [27-36]. Additional impediments to disaster preparation included deficient transportation, insufficient communication, and ineffective incident command systems [33-36]. Cameroon's deficient primary healthcare systems, characterized by insufficient preparation for public health emergencies, impeded health response mechanisms and recovery methods during and after the COVID-19 pandemic [37].

In wars and catastrophes, significant knowledge deficiencies and context-specific constraints within health systems (e.g., governance, finance, workforce, accountability, and service coordination mechanisms) impeded the implementation of primary health care (PHC) [13]. The inadequate comprehension of public health concepts by stakeholders from non-health sectors, coupled with the health sector's siloed methodology, adversely affected integrated disease management during natural disasters [16, 38]. The absence of strategic planning, unclear professional duties, and misalignment of activities with actual requirements impeded the delivery of primary healthcare services to people impacted by the COVID-19 epidemic in several countries [39].

Nonetheless, there were some effective instances of planning for public health emergency responses. Indonesia's decentralized health system governance and fortification, shown by national action plans for health security and preparation exercises, improved disaster preparedness techniques. These solutions included obligatory minimum requirements at the municipal level, linked with a national disaster management framework, decentralized contingency plans, and simulated exercises for prospective public health emergencies. The experience of Shenzhen in coordinating its healthcare system's readiness has aided other cities in improving their response capacity for future catastrophes in China [26]. In Japan, daily post-disaster illness monitoring reporting proved essential for customizing responses to local conditions, forming support networks, and consolidating resources [27]. The proactive reorganization of PHC services facilitated enhanced pandemic preparation, planning, surveillance, and responses for future health system disruptions [28-30].

#### **4. Consequences of public health crises**

The PHEs exert direct effects (e.g., disruption of supply chains and health care provision) and indirect effects (e.g., collateral damage to infrastructure, transportation networks, and communication systems). These effects resulted in the establishment of structural and health disparities. The armed conflict has resulted in a rising number of internally displaced individuals and refugees, causing congestion and strain on existing institutions and service delivery. In the Democratic Republic of the Congo (DRC), hostilities exacerbated the rise in Ebola cases, overwhelming health institutions and amplifying the need for health services [33].

Displaced people resulting from armed conflicts need health services, which may overwhelm health institutions, disrupt service delivery, and complicate the execution of primary health care. Implementation challenges of Primary Health Care (PHC) in Public Health Emergencies (PHE) contexts, particularly during armed conflicts, encompass inadequate preparedness, insufficient shock absorption capacity within the public sector, limited-service provision capabilities, poor adaptability to shocks, failure to restructure damaged facilities, diminished resilience to conflict-related adversities, and the necessity to restore community trust in the public sector [31, 32].

Moreover, both displaced and host populations in conflict-affected areas were deprived of public health services and faced increased susceptibility to diseases and mental health disorders [33, 40]. The impacted people had inadequate access to hygiene and sanitation, such as potable water, and were deprived of primary healthcare services [33, 40]. In Libya, the consequences of conflicts included structural damage to healthcare facilities, a shortage of medical supplies, insecurity for primary healthcare personnel, and inadequate communication, all of which collectively resulted in an increase in neglected and orphaned children and the emergence of atypical infections [41]. In the DRC, comprehensive community mental health services were absent despite a rise in mental health issues resulting from violent conflicts [33].

Armed wars resulted in collateral damage, exacerbating frail health systems and subsequently affecting the access to and provision of health care. In Yemen, the protracted conflict has exacerbated cholera epidemics, straining the healthcare system to address these health demands [42]. In places afflicted by armed conflict, such as during the Ebola outbreak in Guinea, Sierra Leone, and Liberia, health systems weakened, impairing the delivery of important public services to both displaced and host populations [43]. Moreover, disputes impede care accessibility by disrupting supply chain management and short-term initiatives [42, 44]. Factors influencing health care delivery in conflict-affected environments encompass inadequate integrated community health, travel impediments, insufficient supervision and monitoring, threats to health personnel, deficient supply chain management capabilities, lack of quality services, politicization of aid, and elevated care costs [42, 44]. Moreover, social unrest and natural calamities led to persons forsaking or deferring normal healthcare, including mental health treatments [33, 45].

#### **5. Limitations of service provision**

Multiple health system issues impede the delivery of health services in PHEs. In Australia, an insufficiently educated primary healthcare workers heightened the risk of COVID-19 transmission in isolated regions

[46]. The inadequacy of integrated assistance in primary healthcare services has overwhelmed hospital services and heightened the risk of nosocomial infections in Lombardy, Italy [47]. Moreover, disruptions in primary healthcare systems have led to an increase in patients lacking primary healthcare services for the prevention and control of epidemics in Brazil [48]. In Malawi, essential health services were disrupted, resulting in a decline in client attendance at facilities in PHEs [49,51]. The hospital sector was prioritized, leading to inadequate and poorly equipped first care facilities to safeguard personnel and patients from infection while delivering primary care [45, 48].

Moreover, public health emergencies stemming from catastrophic occurrences affected the functions of the healthcare profession, including task reallocation, alterations in job scope, financial pressures, daily unpredictability, and stress. They obstructed the provision of primary care services [49, 50]. Neglected or delayed necessary treatment, absence of gatekeeping, restricted capacity, and inadequate integration between medical care and public health affected the delivery of patient care services [49, 50]. In Sub-Saharan Africa, inadequate investment in health systems and the rise of pandemics underscore the interconnection between the growing prevalence of non-communicable diseases and the burden of communicable diseases, which aggravate adverse health outcomes such as morbidity and mortality [15].

Countries like as Cameroon and the Central African Republic had critical emergency epidemics yet were deficient in primary healthcare services, representing significant gaps in outbreak response. Recent epidemic outbreaks in Ecuador were intensified by inadequate preparedness, insufficient health indicator data, resource shortages (both people and equipment), substandard primary health care services, and a significant rise in pre-existing conditions [34]. During the epidemic, health systems provided extensive services and adapted to the particular demands on resources. Conversely, individuals' lives and the economy were affected by the inconsistencies between service users' claimed behavior and actual practices (e.g., regular mask use) [45, 51]. Moreover, political conflicts and financial resource limitations in enhancing the PHC system hindered and obscured primary care, so affecting the health system's ability to meet health demands and efficiently execute infection control measures [28, 37]. In the context of Ebola response and infection control in Guinea, Sierra Leone, and Liberia, conflicts undermined primary care systems and facilitated the fast proliferation of infections [43].

## **6. Various effects on foundational components**

Public health emergencies, particularly COVID-19, significantly affected all components of health systems. Initially, health systems exhibited insufficient facility preparedness for health services, characterized by a deficiency in material resources (e.g., soap, hand sanitizer, water, masks, equipment, testing materials, and personnel), inadequate infrastructure (e.g., insufficient equipment and space), challenges in procuring test kits and managing turnaround times, overlooked primary health care systems, substandard health service delivery, and inadequate case management and physical distancing measures [47, 51, 52].

Secondly, COVID-19 obstructed the provision of primary health care services and exacerbated health care inadequacies owing to ongoing isolation, lockdowns, and the limitation of essential services, particularly in rural regions of Australia [53, 54]. The COVID-19 pandemic exacerbated the vulnerabilities of existing systems, resulted in an effective lockdown and related collateral damage, and disrupted conventional delivery methods in Sub-Saharan Africa and South Africa. Post-natural catastrophe damage to health infrastructure has precipitated disease epidemics in Ecuador and Ebola-affected nations in Africa [33, 34].

Third, the health staff had significant effects, including a scarcity of clinical personnel; exhaustion and stress due to excessive workloads, stigma, concerns over infection, burnout, mourning, and insufficient training for younger physicians [33, 34, 47, 50-58]. During the COVID-19 epidemic, the Australian health system faced a significant shortage of healthcare personnel, particularly nurses, and depended extensively on temporary workforce solutions, such as fly-in, fly-out or drive-in, drive-out workers, to provide treatment in rural areas of the nation [59,60].

Fourth, during the COVID-19 pandemic, health systems' responses neglected to address their apprehensions and capacity to care for patients amid inadequate data quality and misguided administrative

choices on independent field hospitals and information deficiencies [52, 56]. Contemporary healthcare systems are significantly susceptible to the absence of digital communication technologies [16, 27]. The implementation of remote consulting faced difficulties owing to inadequate digital interoperability, including insufficient digital infrastructure and resources. Elevated data or airtime expenses hindered the enhancement, training, and delivery of care and health education [61, 62].

Ultimately, contemporary global health systems are influenced by a market-driven political economy, which has hindered the provision of primary health care services during a pandemic. Community involvement and support are essential for sustaining service delivery in emergency situations. South Africa saw difficulties in its COVID-19 response because of insufficient collaboration between health systems and communities, together with limited investment in primary health care from the commercial health sector [56]. Insights gained from previous and ongoing pandemics indicate that the inadequacies of global health systems may hinder the management of future pandemics [63, 64]. Health systems also contend with inadequate governance, characterized by heightened corruption in procurement at the national level [60]. Factors contributing to inadequate governance were persistent under-investment, insufficient personnel, lack of cooperation in planning and financing initiatives, rigid billing and record-keeping systems, and low community awareness [44, 60]. Consequently, the private sector may refrain from investing in future public health emergencies and be disincentivized from allocating resources away from commercial ventures. Inadequate capacity, characterized by insufficient resources, infrastructure, and reactive measures, jeopardized the achievement of universal health care. The determinants of inadequate public health response by Primary Health Centers (PHCs) were insufficient collaboration between primary care and public health, lack of resource alignment, and inadequate preparedness of public health institutions [29, 52, 59].

## **7. Escalated health disparities**

The effects of public health emergencies and globalization on trade and commerce also affect the structural determinants of health. The disproportionate allocation of socioeconomic determinants of health fosters new inequalities and exacerbates existing disparities among prioritized groups. PHEs diminish access to services, particularly for marginalized populations, and disproportionately intensify structural (e.g., education and income) and geographical gaps, resulting in heightened health inequities [31, 39, 62-64]. Additional consequences of public health emergencies (e.g., epidemics) included the digital gap (e.g., exclusion of some communities owing to limited digital and Wi-Fi connectivity), inequitable use of available services, and exacerbated, persistent health disparities [39, 62]. The lack of readiness among professionals using digital technology and the tenuous integration of remote and in-person modalities exacerbated health disparities during the COVID-19 pandemic [39]. Global responses did not fulfill the objectives of policymaking for pandemic management, while neoliberal governance strategies exacerbated imbalances that hindered the attainment of Universal Health Coverage (UHC) [12, 62].

## **8. Reactions to the effects of Public Health Emergencies**

The lessons learnt for responding to public health emergencies (PHEs) include planning, integration of primary care and public health, multisectoral collaboration, use of digital platforms, effective communication and partnerships, and the development of resilient health systems. An effective public health emergency response necessitates the integration of public health activities with primary care. The implementation of the PHC strategy associated with socioeconomic determinants of health proved beneficial, with initiatives including investment in public health systems, reorganization of PHC services, and training for front-line practitioners [28, 48, 51]. Moreover, synchronized public health and primary care initiatives might actualize the principles of PHC and ideals for health advancement [38].

The delivery of primary care may facilitate the prevention, protection, promotion, and treatment of sickness in people and communities, hence enhancing social and economic indices [65, 66]. Insights gained from the pandemic response emphasized the enhancement of health systems for primary care in intricate scenarios by integrating public health with primary care and coordinating resources for services—demonstrating a robust capacity for system resilience [67]. During the pandemic response, the participation of health

systems in primary health care initiatives guaranteed a continuous service capable of addressing the evolving health requirements within communities [37, 68].

During a pandemic, the execution and funding of public health and primary care enhanced equity and access, facilitated harmonization, and synergized efforts in establishing healthy societies that responded to emergencies by mobilizing frontline healthcare services, ensuring accountability within health systems, and improving health outcomes [13, 38, 59]. In Sub-Saharan Africa, the COVID-19 epidemic revealed a chance to adopt a community-oriented primary care model and use the enduring advantages of technology breakthroughs [55]. Strategies implemented for primary care and public health encompassed the integration of community-based initiatives, screening and testing, reorganization of health services, preservation of essential and emergency health services, support for vulnerable populations, utilization of information technology, reconfiguration of training opportunities, and strengthening of primary health care institutions. In response to floods, preparation and response strategies were established for facility-specific plans, including standard operating procedures and establishing a chain of command [36].

## **9. Multisectoral initiatives for impactful responses**

Enhancing connections among stakeholders—policymakers, civil society, non-governmental organizations, community-based organizations, and private sector entities—facilitated equity-informed financing models and health systems governance frameworks that diverged from conventional service-oriented primary care. Community responses included involvement, cooperation, and networking to mitigate the collateral effects of catastrophic occurrences. Suburban communities in Israel showed resilience, contentment, and confidence, along with strategies to realign healthcare systems to address individuals' needs during the COVID-19 epidemic [16, 30]. Involving public health stakeholders in community planning enhanced primary care practices and fostered trust across institutions, communities, and health systems [52, 69]. In Cuba, multisectoral measures were implemented in preventive and control, which contributed to alleviating the effect of the COVID-19 pandemic [54].

Mechanisms for equipping agencies to address the incursion of a global pandemic included community partnerships, social networks, social capital, and the importance of primary health care in minority populations during both emergency and regular treatment [30, 70]. In South Africa, extensive multi-sectoral measures successfully mitigated health system vulnerabilities and preserved lives and the economy during the COVID-19 pandemic at the provincial level [56]. Moreover, reinforcing and executing the "One Health" strategy and enhancing PHC institutions allowed nations to address urgent requirements in pandemic preparation [29, 63]. These approaches align with the Sustainable Development Goals, emphasizing the critical role of developmental actions and multi-sectoral collaboration in enhancing coordination, integrating disparate strategies, facilitating knowledge exchange and implementation, and addressing the vulnerabilities of the health system to improve population health and well-being.

## **10. Implications for policy and research**

The majority of the research included in this review focused on the immediate effects of PHEs and their corresponding reactions. Addressing and alleviating these immediate effects is crucial. Nonetheless, understated public health emergencies, including the ramifications of economic crisis mostly in high-income nations, with hunger and malnutrition in low- and middle-income countries, are significant challenges to global health security. Consequently, research must concentrate on the enduring effects of global health security challenges. Acute and chronic public health emergencies result in heightened vulnerabilities and disparities in equity. Addressing chronic public health emergencies requires macro-level, long-term solutions, the use of global institutional frameworks and governance systems, as well as comprehensive global monitoring and surveillance techniques.

## **11. Advantages and constraints of the research**

This review synthesized data from research using various designs and methodology, elucidating results pertinent to public health emergency planning and responses. This study's limitations are the absence of quality rating for individual research in the review and the exclusion of studies published in languages other

than English. Nonetheless, the objective of our assessment was to consolidate the existing information rather than evaluate its quality. We used a systematic scoping review technique to examine the existing evidence in accordance with the PRISMA-ScR guidelines [18, 19], referencing prior scoping reviews [21, 22]. Furthermore, we examined eight databases and conducted a thorough search to ensure the inclusion of the most relevant papers. We identified research pertaining to three public health emergencies (e.g., war, epidemics, and natural disasters); however, other catastrophic occurrences such as financial crises, economic recessions, and hunger are also significant events that might indirectly influence public health services. Consequently, more study should examine other catastrophes that have public health ramifications.

## 12. Conclusions

Public health crises may have various health and ancillary effects in nations with vulnerable health systems, insufficient preparation, and deficient monitoring procedures. Health systems must concentrate on enhancing readiness to withstand the impacts of public health catastrophes, effectively react to them, and adapt to future crises. Potential measures to address consequences may include providing health services tailored to emergency circumstances, monitoring and surveilling epidemics after public health emergencies, and implementing multisectoral initiatives to mitigate collateral harm. Moreover, risk assessment, catastrophe planning, and the implementation of digital alert systems might alleviate future health crises. The responses of Public Health Emergencies (PHEs) necessitate the implementation of a three-pronged strategy: preparedness (e.g., surveillance, health system readiness); immediate response to health impacts (e.g., enhancement of acute health service access); and mitigation of collateral or spillover effects through multisectoral policies and actions.

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الأمن الصحي في مواجهة تغير المناخ: استراتيجيات إدارة التحديات البيئية والطوارئ الصحية العامة

الملخص

**الخلفية:** يواجه الأمن الصحي تحديات متزايدة نتيجة تغير المناخ والطوارئ الصحية العامة (PHEs)، والتي يمكن أن تنشأ عن كوارث بشرية أو طبيعية. تهدد هذه الأزمات النظم الصحية، لا سيما في الفئات السكانية الضعيفة، مما يؤدي إلى تفاقم الفجوات الصحية وتعقيد استجابات الطوارئ

**المنهجيات:** تم إجراء مراجعة موسعة للأدبيات من ثمانية قواعد بيانات إلكترونية (PubMed، Cochrane، CINAHL، EMBASE، Scopus، Web of Science، PsycINFO، و Google Scholar) والأدبيات الرمادية، مع التركيز على الأمن الصحي والرعاية الصحية الأولية (PHC). تضمنت المراجعة تحليل الأثار والدروس المستفادة من مختلف الطوارئ الصحية العامة، بما في ذلك الأوبئة، والنزاعات المسلحة، والكوارث الطبيعية.

**النتائج:** تشير النتائج إلى أن الطوارئ الصحية العامة تعطل الخدمات الصحية الأساسية والبنية التحتية، مما يؤدي إلى زيادة معدلات المرض والوفيات، لا سيما بين الفئات المهمشة مثل النساء والأطفال وكبار السن. وتم تحديد تحديات رئيسية مثل ضعف الاستعداد، ونقص الموارد، وسوء الحوكمة. لوحظت استجابات ناجحة في المناطق التي نفذت تعاونًا متعدد القطاعات واستراتيجيات رعاية صحية أولية متكاملة، مما عزز مرونة النظم الصحية.

**الخلاصة:** يتطلب التعامل مع تقاطع الأمن الصحي وتغير المناخ أطر استعداد قوية ونهجًا متعدد القطاعات لتخفيف تأثيرات الطوارئ الصحية العامة. يجب على الأطراف المعنية إعطاء الأولوية للاستثمارات في النظم الصحية وتعزيز مشاركة المجتمع لتعزيز المرونة وتحسين النتائج الصحية وسط التحديات البيئية المستمرة.

**الكلمات المفتاحية:** الأمن الصحي، تغير المناخ، الطوارئ الصحية العامة، الرعاية الصحية الأولية، المرونة.