

ORIGINAL ARTICLE

Impacts of extreme weather events on health infrastructure and service delivery in rural areas of Ha Tinh Province, Vietnam

Tran Thi Tuyet Hanh¹, Hoang Van Minh¹, Le Thi Thanh Huong^{1*}, Jo-Anne Geere², Brahim Herbane³, Mike Van Der Es², Paul Hutchings⁴, Do Thi Hanh Trang¹, Nguyen Minh Duc⁵, Nguyen Chi Thanh⁶, Nguyen Viet Thang⁵, Ho Thi Tu⁶, Paul Hunter²

ABSTRACT

Objective: This study examined the impacts of extreme weather events (EWEs) in the past five years on infrastructure, service delivery, and workforce in district hospitals and commune health centers (CHCs) in Huong Khe and Huong Son districts, Ha Tinh Province.

Methods: A cross-sectional survey was conducted in December 2024 using structured questionnaires administered to two district hospitals and 46 CHCs. Descriptive statistics, including frequencies and percentages, were used to summarize key indicators to assess damage levels across infrastructure components, disruptions in service capacity, and impacts on staff well-being, and Fisher's Exact Test was used with statistical significance level set at $p < 0.05$.

Results: EWEs caused extensive damage to emergency units, water and electrical systems, and led to service disruptions in over 70% of facilities. Electricity and clean water remained unstable one-week post-event in many facilities. 66.7% of healthcare staff reported physical health impacts, 72.9% experienced psychological distress, and 68.7% reduced working capacity. There were significant associations between infrastructure damage and disruptions in health service delivery.

Conclusion: EWEs disrupted not only infrastructure but also the core functions of service delivery, access to utilities, workforce capacity, and the ability to care for isolated populations. Damage to essential systems, such as clean water, electricity, medical supplies, and communication networks, undermined health system performance in EWEs when it was needed most. EWEs significantly compromised the resilience of the health facilities. Findings demonstrate the urgent need to strengthen climate resilience and disaster preparedness in Vietnam's primary healthcare system. These insights are important for disaster preparedness planning and national health system strengthening.

Keywords: *Extreme weather events, health system resilience, district hospitals, commune health centers, health infrastructure, service delivery, Vietnam*



*Corresponding author: Le Thi Thanh Huong

Email: ltth@huph.edu.vn

¹Hanoi University of Public Health

²University of East Anglia, Norwich, United Kingdom

³De Montfort University, Leicester, United Kingdom

⁴University of Leeds, Leeds, United Kingdom

⁵Ha Tinh Department of Health, Ha Tinh Province, Vietnam

⁶Ha Tinh Provincial Center for Diseases Control, Ha Tinh Province, Vietnam

Submitted: 5 February, 2026

Revised version received: 5 May, 2026

Accepted: 12 May, 2026

DOI: https://doi.org/10.38148/JHDS.102E/SKPT_26_024_E

INTRODUCTION

Climate change has emerged as a defining public health threat of the 21st century, with various climate-sensitive health risks and wide-ranging implications for the health system functioning at different levels. Increasing frequency, intensity, and unpredictability of extreme weather events (EWEs), including floods, storms, hurricanes, typhoons, droughts, and heatwaves are causing rising human health impacts, damaging health infrastructure, and threatening the continuity of essential healthcare services worldwide (1-3). These climate hazards have a detrimental impact on various health services, with disrupted service delivery being the most frequently reported (4). The hazards disproportionately affect low- and middle-income countries (LMICs), where health systems are often under-resourced, infrastructure is more fragile, and adaptive capacity remains limited (5-6). Not only affecting health facilities, climate hazards cause physical, mental health, and occupational safety impacts, which also affect the capacity and resilience of health workers (6-7).

The WorldRiskReport 2024 assessed the disaster risks for 193 countries and Vietnam was among the top 20 countries with the highest risk (8). The country's geographic features including a long coastline, low-lying deltas, and mountainous rural areas render it vulnerable to EWEs. The health consequences of these events are wide-ranging, from immediate trauma and injuries to longer-term impacts such as malnutrition, waterborne diseases, vector-borne diseases, and mental health disorders (9). Projections suggest that by 2050, climate change could reduce national income by up to 3.5% and the Vietnamese health sector will be severely affected, particularly if adaptive measures are not implemented (10-11). In the period 2015-2025, EWEs in Huong Son

and Huong Khe districts killed five people and injured 34 people, while 26,620 houses were flooded, damaged, swept away or had the roofs blown off, and with an estimated damage about 1,638.7 billion VND (12). However, there has been no comprehensive assessment of the impacts of these EWEs on medical facilities and health service delivery in the two districts as well as assessment at commune-level health facilities in Vietnam.

District hospitals and CHCs in Vietnam play a vital role in delivering primary healthcare and emergency services, particularly in remote and disaster-prone areas. However, these facilities often face severe disruptions during EWEs due to inadequate infrastructure, damaged medical equipment, unstable electricity and clean water supplies, and shortages of essential medicines. Moreover, health workers are frequently overstretched, with EWEs exacerbating occupational stress and reducing their capacities to deliver safe and timely care, which was well documented in a recent study in LMICs (6). Despite these vulnerabilities, limited research has systematically documented the direct and indirect impacts of EWEs on the operational resilience of health facilities at the commune and district levels in Vietnam.

This study aimed to assess the impacts of EWEs that occurred between 2019 and 2024 on two district hospitals and 46 CHCs in Huong Khe and Huong Son districts, Ha Tinh Province, one of the most climate-vulnerable regions in north-central Vietnam. The assessment focused on infrastructure damage, service disruptions, impacts on essential utilities, and the physical and mental well-being of health workers. The findings aim to inform national and subnational strategies for climate-resilient health systems in the context of Vietnam's upcoming administrative restructuring and increasing exposure to EWEs, which is important for both policy and practical implications.

RESEARCH METHODS

Research design

This was a cross-sectional study.

Research location and time

This study was conducted in Huong Son and Huong Khe districts, Ha Tinh Province in 2024-2025, with data collected in December 2024.

Research subjects

Directors of Huong Khe and Huong Son district health centers and heads of 46 CHCs and the 48 health facilities (46 CHCs and two district hospitals). All CHCs and district hospitals in Huong Khe and Huong Son districts were included and all completed questionnaires were included for analysis.

Sample size and sampling procedure

All directors and heads of two district health centers and all 46 CHCs were invited to participate in the study.

Variables

Independent variables included general information about the health facilities; the infrastructure of healthcare facilities. Dependent variables included the impacts of EWEs on the service delivery capacity of health facilities, health workers, receive and transportation of patients; responses of health facilities; the physical, mental health and working capacity of health staff. The impacts of the EWE in the assessment were assessed using the Likert Scale (13), which was adapted to measure five levels of impacts of EWEs on healthcare settings, as follows: 1. No impact (approximately 100% as normal conditions); 2. Mild impacts (reduced by approximately 25% of normal capacity); 3. Average impacts (reduced by approximately 50% of normal capacity); 4. Severe impacts (reduced by approximately 75% of normal capacity); 5.

Destroyed (completely inoperative, reduced 100% capacity). When assessing the impact of EWEs on the service delivery capacity of health facilities, health workers, receive and transportation of patients, “severe impact” and “destroyed” was combined into one category.

Data collection and tool

The data were collected by using a self-administered structured questionnaire. The questionnaire was developed based on a review of existing literature, including questions about critical components commonly reported as vulnerable to EWEs, namely (1) physical damages to the CHCs, (2) the impact of the typhoon on health staff, and (3) the impact of an EWE on service delivery one week following the specific EWE (such as strong typhoon, severe flood, severe storm etc.) that occurred most recently in the area in the past 5 years. The first component covered questions about the level of damage to infrastructure of key areas of the health facility such as Reception, Pharmacy, Emergency, etc. The second component involved questions about the impact on physical and mental health and work attendance ability of healthcare staff. The third component covered questions about the impact on different aspects contributing to the operability of the CHC one week following the event such as the number of functional beds, the operability of clinical and preventive services; and the operability of the utility systems. The study questionnaire was sent via emails in December 2024, to be completed within two weeks by the directors/heads of the 48 health facilities.

Data management and analysis: were conducted using STATA 18 software. Descriptive statistics, including frequencies and percentages, were used to summarize key indicators showing the impacts of EWEs on 48 healthcare facilities. The study also

investigated the association between main outcome variables, including damages to infrastructure, and the ability to attend work of the health staff and the operation of key services, using Chi-square test with a P-value less than 0.05 showing evidence of a statistically significant association. Fisher's Exact Test, Odd ratios and 95% confidence intervals were also calculated to demonstrate the strength of the associations. A health facility was considered as being subject to impact on infrastructure if it had at least one area being physically affected at any level, from mild impact to completely destroyed by the EWE.

Ethical consideration

The study protocol was approved by the Ethics Committee of Hanoi University of Public Health (Decision No. 413/2024/YTCC-HD3 dated 31st October 2024). Data were anonymized to ensure confidentiality. Participants were provided written informed consent, which they read, agreed to, and signed prior to the interviews. Participation was entirely voluntary, and participants were informed of their right to withdraw from the study at any time during the data collection without any consequences.

RESULTS

Sample characteristics

The survey was completed by directors/representatives of two district hospitals and 46 CHCs, of which 21 CHCs in Huong Khe District and 25 CHCs located in Huong Son District, with a response rate of 100%. These health facilities had 772 health staff and served a total population of 227,862 people in the two districts. The most recent severe EWEs chosen for assessment by each of the health facilities' director/head were the severe flood that occurred between 28th October and 2nd November 2023, as well as a typhoon or a storm that occurred in the past five years in the two districts.

Impacts of extreme weather events on healthcare facilities

Detailed reported impacts of the most recent severe EWE that occurred in the past five years on the infrastructure of healthcare facilities in Huong Son and Huong Khe districts, Ha Tinh Province, Vietnam are presented in Table 1. The results showed the widespread and multifaceted impacts of EWEs on the infrastructure of district hospitals and CHCs. Nearly all components of these facilities, ranging from essential service areas such as patient reception, emergency units, and pharmacies to critical utilities like water tanks and electrical lines, experienced varying degrees of disruption.

Table 1. Impacts of the most severe recent EWE on the infrastructure of healthcare facilities at Huong Son and Huong Khe districts, Ha Tinh Province (n = 48)

No	Infrastructure	No impact (Approximately 100% as normal conditions)	Mild impacts (reduced ~25% capacity)	Average impacts (reduced ~50% capacity)	Severe impacts (reduced ~75% capacity)	Destroyed (completely inoperative / reduced 100% capacity)
		n (%)	n (%)	n (%)	n (%)	n (%)
1	Patient reception area	8 (16.7)	19 (39.6)	12 (25.0)	7 (14.5)	2 (4.2)
2	Emergency area	12 (25.0)	20 (41.7)	9 (18.7)	6 (12.5)	1 (2.1)
3	Examination and treatment area	11 (22.9)	21 (43.8)	9 (18.7)	6 (12.5)	1 (2.1)
4	Pharmacy counter	15 (31.3)	15 (31.3)	13 (27.1)	4 (8.3)	1 (2.1)
5	Computers, medical records storage	16 (33.3)	17 (35.4)	8 (16.7)	7 (14.6)	0
6	Medicine & supplies storage area (n = 39)	15 (38.5)	14 (35.9)	4 (10.3)	6 (15.4)	0
7	Clean water tank	16 (33.3)	18 (37.5)	9 (18.8)	4 (8.3)	1 (2.1)
8	Waste storage area	5 (10.4)	15 (31.3)	10 (20.8)	14 (29.2)	2 (4.2)
9	Sanitary area	11 (22.9)	17 (35.4)	8 (16.7)	10 (20.8)	2 (4.2)
10	Shelving, cabinets, and equipment	15 (31.3)	17 (35.4)	10 (20.8)	5 (10.4)	1 (2%)
11	Building roofs	8 (16.7)	13 (27.1)	20 (41.6)	3 (6.3)	4 (8.3)
12	Building ceilings	13 (27.1)	9 (18.7)	20 (41.7)	5 (10.4)	1 (2.1)
13	Building walls	9 (18.8)	15 (31.3)	16 (33.3)	8 (16.7)	0
14	Glass doors	11 (22.9)	18 (37.5)	13 (27.1)	2 (4.2)	1 (2.1)
15	Doors	10 (20.8)	22 (45.8)	12 (25.0)	3 (6.3)	0
16	Floors	6 (12.5)	15 (31.3)	12 (25.0)	12 (25.0)	3 (6.3)
17	Air conditioners, fans (n = 47)	14 (29.8)	23 (48.9)	10 (21.3)	0	0
18	Signs	11 (22.9)	18 (37.5)	12 (25.0)	2 (4.2)	1 (2.1)
19	Important area lighting system (n = 42)	10 (23.8)	15 (35.7)	14 (33.3)	3 (7.1)	0
20	Electrical lines	9 (18.8)	17 (35.4)	11 (22.9)	9 (18.8)	2 (4.2)

Key functional areas of health facilities such as the patient reception area, emergency services, and examination rooms were notably affected. Over 75% of these zones reported mild to severe damage, with a small but critical proportion (2.1% - 4.2%) rendered completely inoperative. These impairments could directly threaten timely patient care, triage, and emergency response, particularly during EWE periods when demand usually surges. Structural vulnerabilities were evident in roofs, ceilings, and walls, with 41.6% of roofs and 41.7% of ceilings sustaining average damage, while 8.3% of roofs and 2.1% of building ceilings were destroyed. The sanitary areas and waste storage facilities also suffered high rates of mild to severe impacts (89.6% and 77.1%, respectively), with 4.2% destroyed, raising concerns over infection control and environmental safety during and after EWEs.

Furthermore, essential utilities such as clean water tanks (66.7% impacted) and electrical lines (81.2% impacted) were among the most commonly disrupted components. This highlights the potentially cascading nature of infrastructure breakdown, whereby damage to one system (e.g. electricity) undermines others (e.g. lighting, air conditioning, refrigeration for medicines). Notably, information and communication technology-related components such as computers and medical records systems, while slightly less affected, still showed moderate and severe damage in over 30% of facilities, posing significant risks to continuity of care, data management, and communication during emergencies.

Table 2 presents a detailed overview of how recent EWEs disrupted the operational capacity, service delivery, staffing, and basic

utilities of health facilities. The findings reveal systemic strain on the healthcare system's ability to function effectively during and after such events. One of the most concerning findings is the marked reduction in operational hospital bed capacity during EWEs. 72.9% of facilities reported a loss of up to 75% of bed functionality, with 16.7% reporting severe operational shutdowns. Although bed capacity showed partial recovery within one-week post-event, nearly 40% of facilities continued to experience reduced bed availability, limiting surge capacity and emergency preparedness (Table 2). Core health services, including patient reception, medical examination, treatment, and emergency care were significantly disrupted. 97.9% of health facilities reported impacts on patient reception, with 14.6% experiencing severe disruption. Similarly, 83.3% of facilities saw compromised emergency care, including 10.4% reporting near-total incapacity, disrupting urgent clinical response during crises. Laboratory diagnostics and treatment services were also impaired in over 80% of facilities, which could affect timely case identification and intervention.

Disruptions extended to health workforce availability, where 54.2% of facilities experienced staff shortages due to displacement, inaccessibility, or physical/mental stress. The ability of health workers to perform their duties under EWE conditions is not only a measure of infrastructure resilience but also reflects deeper human resource and occupational vulnerabilities in disaster-prone regions.

Table 2. Impact of EWEs on the service delivery capacity of health facilities, health workers, receive and transportation of patients (n = 48)

No	Impacts of EWEs on healthcare facilities and health staff	No impacts (Approximately 100% as normal conditions)	Mild impacts (reduce ~25% capacity)	Average impacts (reduce ~50% capacity)	Severe impacts - Destroyed (reduce 75%- 100% capacity)
1	Number of hospital beds operational during EWEs compared to normal conditions	13 (27.1%)	20 (41.7%)	7 (14.5%)	8 (16.7%)
2	Emergency area	30 (62.5%)	9 (18.8%)	7 (14.5%)	2 (4.2%)
3	Examination and treatment area				
	<i>Impacts on patient reception activities</i>	1 (2.1%)	21 (43.7%)	19 (39.6%)	7 (14.6%)
	<i>Impacts on sampling and medical testing activities</i>	8 (16.7%)	10 (20.8%)	11 (22.9%)	2 (4.2%)
	<i>Impacts on emergency care for patients</i>	8 (16.7%)	19 (39.6%)	15 (31.3%)	5 (10.4%)
	<i>Impacts on medical examination activities</i>	1 (2.1%)	21 (43.7%)	20 (41.7%)	6 (12.5%)
	<i>Impacts on patient treatment activities</i>	4 (8.4%)	22 (45.8%)	16 (33.3%)	6 (12.5%)
4	Impacts on the number of medical staff	22 (45.8%)	11 (22.9%)	12 (25%)	3 (6.3%)
5	Access to clean water for health facilities one week after the EWE	15 (31.3%)	23 (47.9%)	5 (10.4%)	5 (10.4%)
6	Access to electricity at health facilities one week after the EWE	16 (33.3%)	15 (31.3%)	8 (16.7%)	9 (18.7%)
7	Access to health service contact information and communication one week after the disaster	13 (27.1%)	23 (47.9%)	8 (16.7%)	4 (8.4%)
8	Impact on medical equipment, drugs, and supplies	20 (41.7%)	19 (39.6%)	5 (10.4%)	4 (8.4%)
9	Impacts on equipment in the sterilization room	14 (29.2%)	19 (39.6%)	11 (22.9%)	4 (8.4%)
10	Impacts on sanitation conditions, waste collection, and treatment	7 (14.6%)	25 (52.1%)	10 (20.8%)	6 (12.5%)
11	Impacts on the ability to receive and transport patients				
	<i>Impacts on the ability to receive patients requiring first aid</i>	12 (25%)	22 (45.8%)	8 (16.7%)	6 (12.5%)
	<i>Ability to transport patients to higher-level medical facilities</i>	16 (33.3%)	18 (37.5%)	8 (16.7%)	6 (12.5%)

In terms of essential infrastructure and utilities, clean water and electricity access were compromised in over 65% of facilities, with 10.4% - 18.7% experiencing severe outages even a week post-event. Communication and health information systems, which are vital for coordination during emergencies, were affected in 72.9% of facilities, of which 8.4% were severely affected one week post EWEs. Medical supplies, drugs, and sterilization equipment suffered moderate to severe impacts in nearly half of the facilities, raising concerns about safe and effective care delivery. Transportation and referral

pathways were significantly impaired, with 75% and 66.7% of facilities reporting difficulty receiving patients requiring first aid or transferring them to higher-level care, respectively.

This study also explored the response of healthcare facilities in the context of people being isolated in the community due to EWEs. The results are presented in Figure 1. The findings reflected the extent to which primary healthcare providers acted as lifelines, ensuring continuity of care despite severe logistical constraints.

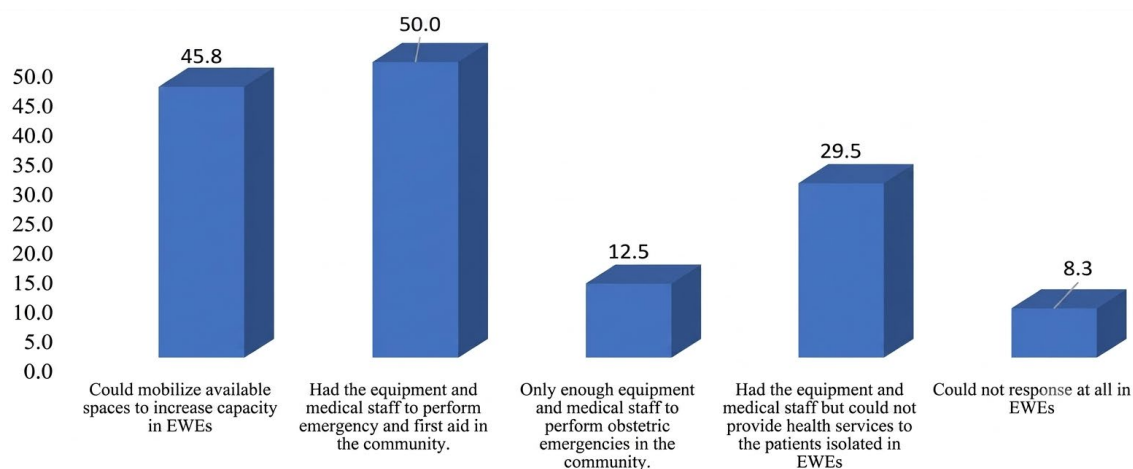


Figure 1. Response of healthcare facilities in the context of people being isolated in the community due to EWEs (n = 48)

However, the variation in response capacities across facilities points to significant inequities in resource availability, preparedness protocols, and personnel training. Among 48 facilities, only 45.8% of facilities could mobilize available spaces to increase capacity in EWEs and 50% had equipment and medical staff to perform emergency and first aid for patients isolated

in the communities. Only 12.5% of facilities had enough equipment and medical staff to perform obstetric emergencies in the community. Close to one-third (29.5%) of health facilities had equipment and medical staff but could not provide health services to the patients being isolated in EWEs and 8.3% of the health facilities could not respond at all in EWEs.

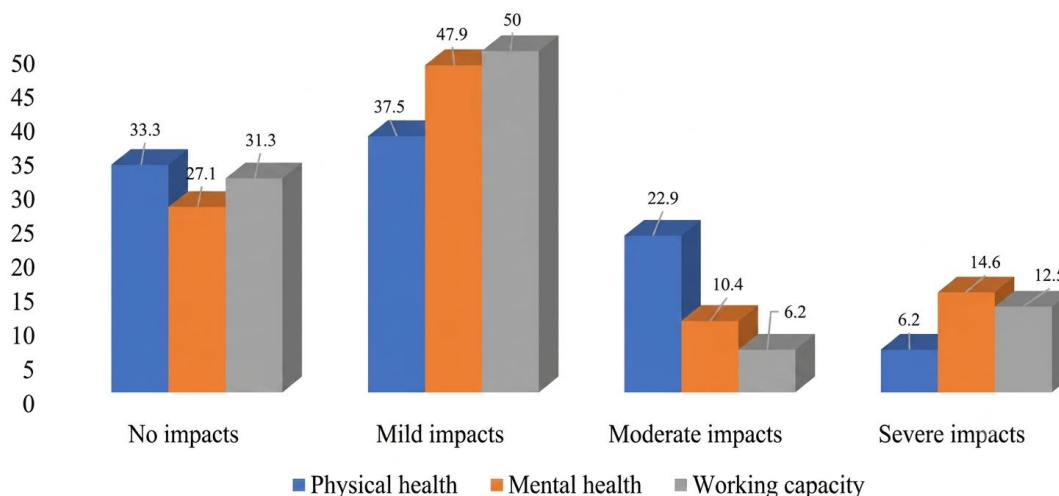


Figure 2. Impacts of EWEs on the physical, mental health and working capacity of health staff (n = 48)

Figure 2 illustrates the profound toll that EWEs impose on the health workforce, not only in terms of operational disruptions but also through physical and psychological strain. The figure reveals that a substantial proportion of health workers experienced fatigue or physical health impacts (66.7%), emotional distress or mental health impacts (72.9%), and reduced working capacity (68.7%) during and after EWEs.

Table 3 demonstrates significant associations between infrastructure damage and

disruptions in health service delivery. CHCs experiencing infrastructure impacts were substantially more likely to report reductions in operational capacity. Specifically, CHCs with infrastructure damage had 1.82 times higher odds of having reduced bed availability within one-week post-EWEs (OR = 1.8, 95% CI: 1.4-2.4, $p = 0.02$). Similarly, disruption to access to clean water was also significantly associated with infrastructure impacts; CHCs affected by infrastructure damage had 10.3 times higher odds of reporting limited access to clean water (95% CI: 1.8-60.3, $p = 0.008$).

Table 3. Associations between impact on infrastructure and impacts on activities of CHCs in EWEs

Impact on services and health staff		Impacts on infrastructure		n	OR (95%CI)	P
		No N (%)	Yes n (%)			
Number of beds in operation after 1 week post EWEs*	No impact	8 100%	22 55%	30	1.8 (1.4-2.4)	0.02
	Impact	0 0%	18 45%	18		
Access to clean water*	No impact	6 75%	9 22.5%	15	10.3 (1.8-60.3)	0.008
	Impact	2 25%	31 77.5%	33		

(* Fisher's Exact Test)

Table 4 illustrates the significant associations between health workers' ability to attend work during EWEs and disruptions to some key health services at CHCs. Table 4 shows that CHCs where health workers experienced difficulties attending work were 5.6 times more likely to report disruptions in emergency

care services compared to those where staff attendance was unaffected (OR = 5.6, 95% CI: 1.1–27.9, $p = 0.04$). Additionally, CHCs with reduced staff availability due to EWEs were 8.3 times more likely to report compromised ability to approach patients requiring first aid (OR = 8.3, 95% CI: 1.9–35.6, $p = 0.004$).

Table 4. Associations between health workers' ability to attend work and impact on emergency care and first aid

Impact on some key services		Impact on health workers' ability to attend work		n	OR (95%CI)	P
		No N (%)	Yes n (%)			
Emergency care at the commune health center*	No impact	5 35.7%	3 9.1%	8	5.6 (1.1-27.9)	0.04
	Impact	9 64.3%	30 90.9%	39		
Ability to approach patients requiring first aid*	No impact	8 53.3%	4 12.1%	12	8.3 (1.9-35.6)	0.004
	Impact	7 46.7%	29 87.9%	36		

(* Fisher's Exact Test)

DISCUSSION

This study provides evidence of the widespread and multifaceted impacts of EWEs on district hospitals and CHCs. Our findings demonstrated the systemic fragility of primary healthcare infrastructure and services under EWEs. The results showed that the structural integrity of healthcare facilities was compromised across nearly all functional domains. As shown in Table 1, critical service areas, such as patient reception, emergency departments, treatment rooms, and pharmacies sustained moderate to severe damage in a large proportion of facilities, with several reporting destruction. These vulnerabilities are particularly alarming given their central role in triage, emergency care, and ongoing treatment. The high incidence of damage to utility systems, including electrical lines, clean water tanks, and sanitation infrastructure, reveals

interdependencies that, when disrupted, cascade into service failure. These findings mirror global evidence and recommendations that infrastructure resilience is critical to climate-adaptive health systems, especially in low-resource settings (14, 15).

In addition, the capacity of health facilities to deliver care during and after EWEs was severely constrained, as highlighted in Table 2. Most facilities experienced a marked reduction in available hospital beds during EWEs, with limited recovery even one-week post-disruption. Core health services, including patient reception, emergency response, laboratory diagnostics, and treatment services were affected in 97.9%, 83.3%, and over 80% of facilities, respectively, reflecting a critical interruption of essential care. Medical supply chains and sterilization functions were also impaired,

potentially increasing the risks of healthcare-associated infections and medication shortages during peak demand. Data in Table 2 reinforce that EWEs compromise not only physical infrastructure but also the operational core of health services, including clinical workflows, staff availability, resource continuity, and emergency response systems. This shows the need to integrate climate resilience and disaster preparedness into health system planning, especially for commune-level facilities that serve as the frontline during EWEs. These findings align with prior studies emphasizing that EWEs can significantly reduce health service continuity and clinical quality (4, 16).

Our findings also highlight the fragility of essential systems required to maintain basic operations and connectivity such as electricity, clean water and communication systems. These disruptions not only hinder routine operations but also delay coordination with higher-level referral centers, reducing the timeliness and effectiveness of emergency response efforts. A study by Rodríguez-Madera et al. (2021) (17) showed that in the aftermath of Hurricane Maria in Puerto Rico, the prolonged power outages significantly impeded patient care and communication with referral centers, were partly responsible for the death of 3,052 people due to extended interruptions in access to medical care. Of particular concern is the inability to receive or transfer patients in need of urgent care, as reported by 75.0% and 66.7% of facilities, respectively, further compounding the health risks faced by isolated communities during EWEs. The results in Table 3 also indicated that infrastructure resilience seemed to critically linked to the continuity of essential health services in rural CHCs during and after EWEs. Health facilities experiencing infrastructure damage were more likely to suffer operational disruptions.

Furthermore, EWEs tend to exacerbate

pre-existing weaknesses in health systems. Without resilient infrastructure, health systems will face increasingly frequent service interruptions as global temperatures rise and EWEs increase in frequency and severity (18). Furthermore, Figure 1 demonstrates the uneven response capacity of facilities in the face of community isolation. While some facilities adopted proactive strategies, such as pre-positioning medical supplies and utilizing local networks to reach patients, these practices were not uniformly implemented across 48 studied health facilities in the two districts. 8.3% of the health facilities could not respond at all in EWEs. The findings in Figure 1 emphasized the urgent need to institutionalize protocols for isolated care delivery in Ha Tinh province. A recent study in Central Vietnam showed that clear legal frameworks, public transparency in resource allocation, active multi-stakeholder collaboration, and localized governance approaches that empower community involvement were enablers in implementing effective disaster risk management (19).

The toll on health workers themselves in EWEs also demands attention. As shown in Figure 2, EWEs significantly affected the physical and mental health of frontline staff, which could lead to fatigue, emotional distress, and reduced working capacity. Reduced physical stamina and compromised working capacity during EWEs could directly threaten the quality and safety of health service delivery, particularly in resource-limited settings already operating at the margin of capacity. These effects directly threaten the continuity and quality of healthcare service delivery. Yet, disaster preparedness policies in Vietnam such as the National Action Plan for the Health Sector Response to Climate Change in the period 2019-2030, with a vision to 2030 have not included occupational health and psychosocial support systems tailored to the needs of health personnel (20). Thus, long-term strategies must go beyond

infrastructure to include psychosocial support systems, emergency staffing models, and training in occupational health and stress management. The elimination of district-level administration and merging of communes together from July 1, 2025 (21) meant that all disaster risk reduction systems, including plans, personnel, and command protocols must be revised and adapted to a two-tier structure. Thus, the efforts in strengthening resilience in healthcare settings at the commune level are especially urgent as the country undergoes administrative restructuring, offering a window of opportunity to embed climate resilience into future health governance reforms.

Limitations

Although this study found interesting results, several limitations should be acknowledged. Impacts of recent EWEs on healthcare settings and service delivery were self-reported by heads of CHCs and directors of district hospitals and may be subject to recall or reporting bias.

The cross-sectional design limited causal interpretation and a small number of 48 health facilities was another limitation of this study, particularly for statistical inference. Additionally, the questionnaire used in this study was based on a review of existing literature on impacts of EWEs on health facilities rather than a validated, standardized tool approved by relevant organizations. Furthermore, this study was only an initial quantitative assessment on the impacts of EWEs on various aspects of health facilities using a questionnaire rather than an observational checklist conducted immediately or shortly after the EWEs. Future assessments, possibly qualitative studies and assessment using a direct observation checklist with a larger sample size will be needed to better quantify the impacts and to examine the factors that explain these losses as well as assess whether infrastructure

impacts relate to service delivery impacts.

CONCLUSIONS

This study highlights significant vulnerabilities of primary healthcare facilities in two disaster-prone districts of Ha Tinh Province under increasing EWEs. Floods and storms disrupted essential health system functions, including healthcare delivery, electricity, clean water, medical supplies, communication systems, and emergency transport, particularly affecting isolated rural communities. Many CHCs lacked resilient infrastructure, backup utilities, emergency supplies, and sufficient workforce capacity to maintain services during disasters.

The findings indicate an urgent need to strengthen commune-level preparedness through climate-resilient infrastructure, improved emergency logistics, reliable backup systems, and stronger coordination between the health sector, local authorities, and community response networks. These actions are especially important in the context of Vietnam's new two-tier administrative system implemented from 1 July 2025, which may affect local disaster response and health service delivery. Overall, developing a targeted climate-resilient primary healthcare strategy is critical to ensure service continuity during future climate-related emergencies.

Acknowledgments

We would like to thank colleagues at the Ha Tinh Provincial Centre for Disease Control, Ha Tinh Department of Health, Huong Son and Huong Khe District Medical Centres, commune health stations in Huong Son and Huong Khe districts for their cooperation and participation in this study. The authors gratefully acknowledge the valuable contributions of Mrs. Lai Thi Huong- the Project administrative staff at Hanoi University of Public Health, community representatives and the research

team members and in Ha Tinh Province: Mr. Tran Quoc Bao – Vice Chairman of Huong Khe People’s Committee, Mr. Nguyen Truong Lam – Director of Huong Khe District Medical Centre, Mr. Luong Son Hung – Head, Department of Disease Prevention and Control/HIV-AIDS, Huong Khe District Medical Centre; Mr. Ho Thai Son – Vice Chairman of Huong Son People’s Committee, Mr. Le Nhat Thanh – Director of Huong Son District Medical Centre, Mr. Doan Dai Nghia – Deputy Head, Department of Human Resource and Administration, Huong Son District Medical Centre. The authors also wish to thank all participants for active involvement in this study.

This work was supported by the National Institute for Health Research (NIHR) under project application NIHR204820, dated 31/01/2023, Amending Correspondence, 21/08/2023. Any views expressed in this report are those of the research team members and not the NIHR.

Conflict of interest

The authors of this study declared no conflicts of interest to the research, authorship, and publication of this manuscript.

REFERENCES

1. Adil L, Eckstein D, Kunzel V, Schafer L. Climate Risk Index 2025 – Who suffers most from extreme weather events. 2025.
2. Romanello M, Napoli C, Green C, Kennard H, Lampard P, Scamman D, et al. The 2023 report of the Lancet Countdown on health and climate change: the imperative for a health-centred response in a world

facing irreversible harms. *Lancet*. 2023;402(10419):2346-94.

3. Bell J, Brown C, Conlon K, Herring S, Kunkel K, Lawrimore J, et al. Changes in extreme events and the potential impacts on human health. *J Air Waste Manag Assoc*. 2018;68(4):265-87. doi: 10.1080/10962247.2017.1401017
4. Gkouliaveras V, Kalogiannidis S, Kalfas D, Kontsas S. Effects of Climate Change on Health and Health Systems: A Systematic Review of Preparedness, Resilience, and Challenges. *Int J Environ Res Public Health*. 2025;22(2):232. doi: 10.3390/ijerph22020232.
5. Naser K, Haq Z, Naughton B. The Impact of Climate Change on Health Services in Low- and Middle-Income Countries: A Systematised Review and Thematic Analysis. *Int J Environ Res Public Health*. 2024;21(4):434. doi: 10.3390/ijerph21040434.
6. Salam A, Wireko A, Jiffry R, JC N, Patel H, Zahid M, et al. The impact of natural disasters on healthcare and surgical services in low- and middle-income countries. *Ann Med Surg* 2023;85(8):3774-7. doi: 10.1097/MS9.0000000000001041
7. Tesfaye AH, Prior J, McIntyre E. Impact of climate change on health workers: a scoping review. *Journal of Public Health*. 2025. <https://doi.org/10.1007/s10389-025-02418-z>
8. Bündnis Entwicklung Hilft / IFHV. *WorldRiskReport*. Berlin: Bündnis Entwicklung Hilft 2024.
9. Nu Quy Linh Tran, Huynh Thi Cam Hong Le, Cong Tuan Pham, Xuan Huong Nguyen, Ngoc Dang Tran, Tuyet-Hanh Thi Tran, et al. Climate change and human health in Vietnam: a systematic review and additional analyses on current impacts, future risk, and adaptation. *Lancet Reg*

- Health West Pac. 2023;40:10094. doi: 10.1016/j.lanwpc.2023.100943.
10. World Bank. Vietnam: Climate risk country profile. 2021.
11. Arndt C, Tarp F, Thurlow J. The economic costs of climate change: A multi-sector impact assessment for Vietnam. *Sustainability*. 2015;7:4131–45. <https://doi.org/10.3390/su7044131>
12. Tran Thi Tuyet Hanh, Hoang Van Minh, Le Thi Thanh Huong et al. Report on natural disasters and extreme weather events in Huong Son and Huong Khe Districts, Ha Tinh Province in the period 2015-2025. Hanoi: Hanoi University of Public Health; 2025.
13. Likert R. A Technique for the Measurement of Attitudes. *Archives of Psychology*. 1932;22(140):1-55.
14. Mosadeghrad AM, Isfahani P, Eslambolchi Lea. Strategies to strengthen a climate-resilient health system: a scoping review. *Globalization and Health*. 2023;19:62. doi: 10.1186/s12992-023-00965-2
15. World Health Organization. WHO guidance for climate-resilient and environmentally sustainable health care facilities. Geneva: WHO; 2020. Contract No.: CC BY-NC-SA 3.0 IGO.
16. Dewi SP, Kasim R, Sutarsa IN, et al. A scoping review of the impact of extreme weather events on health outcomes and healthcare utilization in rural and remote areas. *BMC Health Serv Res* 2024;24:1333. Doi: 10.1186/s12913-024-11695-5
17. Rodríguez-Madera SL, Varas-Díaz N, Padilla M, Grove K, Rivera-Bustelo K, Ramos J, et al. The impact of Hurricane Maria on Puerto Rico's health system: post-disaster perceptions and experiences of health care providers and administrators. *Glob Health Res Policy*. 2021;6(1):44. doi: 10.1186/s41256-021-00228-w.
18. Romanello M, McGushin A, Napoli CD, et al. The 2021 report of the Lancet Countdown on health and climate change: code red for a healthy future. *The Lancet*. 2021;398(10311):1619-62. doi: 10.1016/S0140-6736(21)01787-6.
19. Bien Thanh Vu, Obaitor OS, Grobusch LC, Sett D, Hagenlocher M, Schinkel U, et al. Enablers and barriers to implementing effective disaster risk management according to good governance principles: Lessons from Central Vietnam. *Int J Disaster Risk Reduct*. 2025;120:105344. Doi: 10.1016/j.ijdrr.2025.105344
20. The National Action Plan for the Health Sector Response to Climate Change 2019-2030, with a vision to 2050, No. 7562/QĐ-BYT dated 21 December 2018 (2019).
21. The conclusion of the Politburo and the Secretariat No. 137-KL/TW dated March 28, 2025 on the Project on rearranging and reorganizing administrative units at all levels and building a 2-level local government organization model, (2025).