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Public Health Crises from Floods in Pakistan: Climate Risks, Health Outcomes, and Pathways to Resilience

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ABSTRACT

Pakistan's increasing vulnerability to climate-induced flooding presents a severe public health challenge, with devastating consequences for population health. The literature based research highlights the public health crisis, damages and climate risk associated with flood. For the purpose, the research examines the 49 peer reviewed studies to assess the health risks associated with flood. For the purpose, the search strategy included Google Scholar, Web of Science, Science Direct, Scopus to gather the appropriate data, whereas, the non-relevant data were excluded from the strategies. The analysis reveals three critical health consequences: (1) acute physical trauma and drowning incidents during flood events, (2) secondary outbreaks of waterborne (cholera, hepatitis E) and vector-borne (dengue, malaria) diseases in post-flood periods, and (3) chronic mental health conditions among displaced populations. Besides that, the psychological, mental, social impacts were deemed to be the observed due to the flood. Particularly affected are marginalized communities with limited access to healthcare, proper sanitation, and stable housing. The findings highlight systemic weaknesses in disaster preparedness, including inadequate medical supply chains, insufficient emergency healthcare infrastructure, and fragmented disease surveillance systems. These results argue for comprehensive policy reforms that combine climate adaptation strategies with strengthened public health systems, emphasizing community-based preparedness programs and targeted protection for high-risk groups. Therefore, the study recommends the policies for mitigating the flood related diseases as well as preparedness before flood for the sustainable development.

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Introduction

Climate change represents one of the most critical global challenges as a whole. The impacts of climate change are threatening the sustainability of ecosystems and livelihoods, especially

in rural communities in developing countries (Khoso et al., 2024). While, in Pakistan, the climate change impacts have been observed to be the hectic for local residents and have been severely become more evident recently in terms of flood disaster on Indus River. Over the past decade, these floods have wreaked chaos on infrastructure and local communities. Regardless of geographical location or socio-economic status, the impacts of climate change are widespread, affecting food security, access to clean water, human health, ecosystems, and the livelihoods of species (Bhutto et al., 2024). It was well observed that, the human activities has also been a major concern and the biggest reason for the climate change due to the deforestation as well as increasingly use of gasses/fuels (Khushi et al., 2024). Political and governmental factors can complicate the health risks faced by communities affected by such disasters, rather than helping to cope with them, making it more difficult for them to adapt to changes in the environment and recover. The increase in extreme weather events, coupled with the lack of appropriate flood management strategies in urban policies, has raised global awareness of the increasing risks posed by climate change.

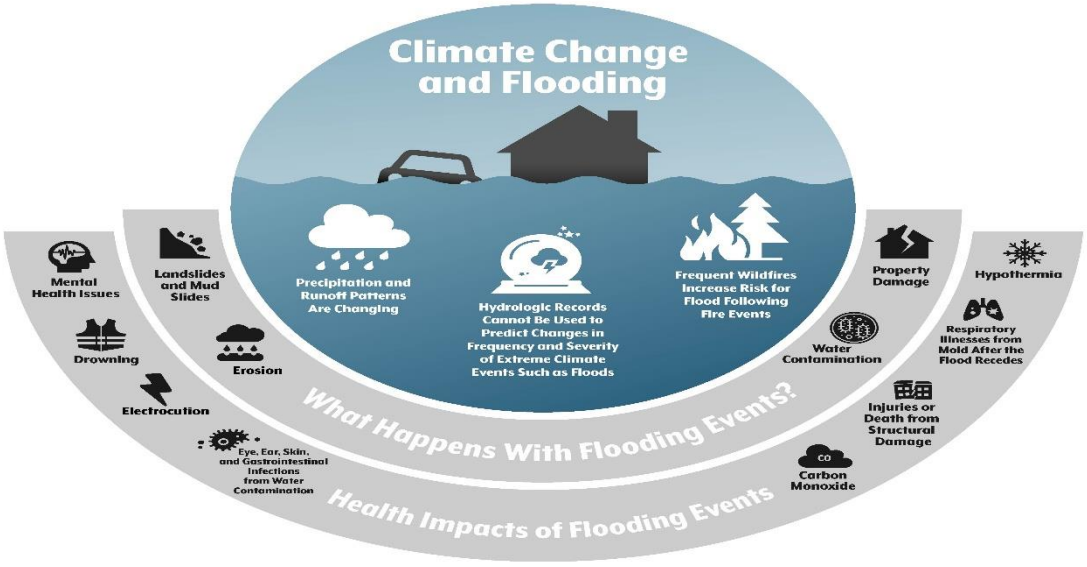

Figure 1: Climate Change and Flooding
Source: (Chrissy , 2021), *Colorado health institute*

The figure-1 shows the climate change and flooding provide comprehensive information about flood events occurrences as well as health damage (Chrissy, 2021). Floods have considered being the social challenge in terms of serious health risks to health/ death as well as damages to the shelters. The Himalayan region, home to vast glaciers, is becoming increasingly vulnerable to rising temperatures as they threaten vital natural resources while, floods have most of the times happened due to the high rainfalls. As, it was well noted in 2022 flood, that the heavy rainfalls have worsen the situation of the local residents in all over the Pakistan specifically Sindh, which has not only affected the well-being but also increased the high temperature in terms of climate change. These include flash floods due to rapid glacier melting, more intense monsoons, prolonged heat waves, water scarcity, droughts, particularly in Sindh. These changes are contributing large-scale resettlement of individuals as well as families. In addition, Pakistan's land administration system, which is rooted in colonial-era practices and lacks judicial reform, is creating difficulties for the growing urban population (Vighio et al., 2024). This failure to address land management and urban development issues

had concerned to be the liability to boost hazards of communities to environmental disasters. Floods have been identified by the scientific community as a major contributor to poor health outcomes, particularly in low-income areas (Plate, 2002). SO far, the climate change and related impacts worsen the unpredictable changes in environmental conditions, which are already having a detrimental impact on well-being. Each year, floods cause a number of diseases and increase mortality rates, while those who survive continue to face health risks. Given the widespread and devastating nature of flooding, it has become a global issue that demands coordinated international efforts to reduce its impacts. In addressing this challenge, it is crucial to consider what types of evaluations and strategic planning are needed to mitigate the effects of floods on public health, particularly as climate change continues to alter environmental patterns. The involvement of every individual is important in the collective response to this growing threat.

Review of Literature

Floods (2003-2022)

Since its creation, Pakistan has faced a variety of natural disasters, including floods, earthquakes, windstorms, and droughts. These catastrophic events have caused extensive damage to infrastructure, livelihoods, health systems, education, communication networks, and businesses (Mahesar, 2022). Pakistan is home to the largest number of glaciers outside the Polar Regions, making it particularly vulnerable to floods and other water-related disasters. The monsoon season, coupled with the impacts of climate change, exacerbates socioeconomic challenges and has a significant effect on public health (Rahman et al., 2019). Many areas of Pakistan are frequently affected by flooding. For instance, in 2003, an above-average monsoon season caused widespread flooding in Sindh Province (Kazi, 2014). Urban flooding also severely impacted Karachi, where two days of heavy rainfall (284.5 mm or 11.2 inches) left the city in ruins. The situation was even worse in Thatta District, where 404 mm (15.9 inches) of rain led to devastating flash floods. The floods resulted in at least 484 deaths and damaged thousands of towns across the province (Islamic Relief Worldwide, 2009; Monson, 2011). In July and August, the region of Khyber Pakhtunkhwa experienced significant disruption due to melting glaciers and intense rainfall, while Sindh and coastal Balochistan were severely affected by a cyclone in June, followed by heavy rains in the subsequent months. During this period, over 2,000 people were forced to evacuate their homes, and at least 130 people drowned in Khyber Pakhtunkhwa (Lashari & Khero, 2010). Flash floods in Balochistan and Sindh led to the deaths of 815 individuals. According to a report by Shreshta (2008), Pakistan ranks as the third most flood-prone country in South Asia, following Bangladesh and India. The devastating floods of 2010, triggered by unprecedented rainfall in Khyber Pakhtunkhwa and Punjab, had widespread impacts, affecting nearly the entire country. This disaster caused more people to suffer than the combined toll of the Indian Ocean disasters of 2004 (Zaidi, 2010). Around 20 million individuals were impacted by the flood, with at least 2,000 fatalities (Pakistan Flood, 2010). While direct deaths and injuries from the 2010 flood were relatively low, with one in every 10,000 affected, the long-term health consequences were substantial. A survey showed that 77% of households reported injuries or health issues linked to the flooding (Kirsch et al., 2012). In September 2011, another major flood struck Sindh province due to monsoon rains, leading to at least 361 deaths, displacing 5.3 million people, damaging over 1.2 million homes, and destroying 1.7 million acres of agricultural land. In September 2012, monsoon rains triggered severe flooding across Khyber Pakhtunkhwa, southern Punjab, and northern Sindh, leading to widespread destruction. Thousands of homes were damaged or destroyed, large swaths of

agricultural land were inundated, and over 100 people lost their lives (Dawn, 2012). Baqir et al. (2012) observed that following environmental disasters such as floods, there is a significant rise in the incidence of various acute and subacute illnesses, including leptospirosis, skin and eye infections, diarrhea, leishmaniosis, malaria, and respiratory illnesses. In September 2014, heavy rainfall resulted in flooding across Jammu and Kashmir, as well as parts of Punjab, with particular devastation along the River Chenab and Jhelum (BBC, 2014). The aftermath of such disasters often includes an increase in traumatic injuries, chemical exposures, hunger, and mental health issues (Bandino et al., 2015; Daniel et al., 2021). Paavola (2017) highlighted the adverse effects of severe climate events on human health, noting that such conditions exacerbate vulnerabilities related to weather and environmental stressors. Floods can have a significant impact on public health, not only in the immediate but also in the long term when floodwaters spread sewage and contamination to drinking water supplies, the risk of infectious diseases increases. In addition, floods put a great strain on the health sector, as critical infrastructure is often destroyed, and medical facilities are either not functioning or are inadequate to meet treatment needs. Floods can also damage hospitals, clinics and health systems, making it difficult for health workers to access essential resources and equipment. As noted in Khoso et al. (2024), flood damage severely hampers the ability of health services to function effectively, especially in the affected areas.

Flood as a main cause of damage

Floods have inflicted severe damage on buildings and critical infrastructure, disrupting essential social services and exacerbating public health challenges. Over the past twenty years, floods have impacted an estimated 2.3 million people worldwide, highlighting their far-reaching consequences on health and well-being. In August 2020, Karachi experienced a historic weather event when the city recorded 231 mm of rainfall in less than 12 hours, the highest single-day rainfall in the city's history. The total rainfall in Karachi that month reached 484 mm (19 inches), a level not seen in the past 90 years. Most of the geographies including villages as well as urban areas had been in big damage due to the water flow from the rain including infrastructure and the agriculture. This widespread flooding disrupted the lives of countless residents. The summer of 2022 saw catastrophic flooding across much of Pakistan, with Balochistan and Sindh being the hardest-hit provinces, though the effects were felt as far north as Kashmir. The floods resulted in the deaths of at least 1,500 people, and approximately 16 million children were affected (Ahmed, 2022). These floods were the result of the heaviest monsoon rains ever recorded, causing widespread destruction and affecting nearly one in seven people, or around 33 million individuals. Nearly 8 million people were displaced, and despite ongoing relief efforts, around 15 million people continued to face the risk of flooding or lived in precarious conditions nearby. By October 11, more than 1,700 lives had been lost, with children representing roughly a third of the casualties. In response, the government declared 94 districts, mostly in Balochistan, Sindh, and Khyber Pakhtunkhwa, as "calamity struck," which accounted for over half of the country's districts (Pakistan Flood, 2022).

Floods and Health Concerns

The COVID-19 pandemic was the first major disaster in recent years, followed by devastating floods. Both of these crises were poorly managed by political leaders, which have had serious consequences for public health and well-being (Rehman, 2022). Geddes (2022) reported that the flooding in October caused damage to 10% of healthcare facilities in Pakistan. The devastation has also resulted in the loss of crucial medical equipment and

supplies. With nearly 50% of the population already struggling to access basic healthcare, the destruction of more than 2,000 hospitals and clinics has further overwhelmed the nation's weakened health system. In flood-stricken regions, healthcare workers have adapted their approaches to maintain medical services, striving to ensure continuity in vital immunization programs, including polio vaccination campaigns. However, the widespread displacement of people and the reduced access to healthcare facilities have increased the risk of disease outbreaks, making it more difficult to reach unvaccinated populations.

Challenges faced by the local people by floods

In addition to these challenges, political issues in Pakistan have exacerbated the situation. Rehman (2022) highlighted that the country's political landscape generally ignores the needs of ordinary citizens, and the government's inadequate response to flood-related health issues demonstrates how politics can impact the health system. According to Pakistan Floods (2022), the severity of the floods highlights the need for systemic reforms to address vulnerabilities that increase the impact of natural disasters. There is an urgent need to change development planning and resource management to incorporate resilience to such events. Besides that, flood provides a lot of challenges including the displacement causing loss of crops, health concerns including diarrhea, skin irritations, damages to women at greater extent (Khan, 2022). So far, the women during pregnancy also suffer from flood related disasters specifically in birth time as well as safety provided them during floods (UNFPA, 2022).

Challenges related to mobility and displacement in flood-affected areas increase health risks for these communities (Paolo, 2017). Besides that, the ratio of flood related disaster in connection with morbidity has surged a great worries for well-being. Floods can have serious public health impacts, making it important to incorporate these challenges into disaster management strategies. After extensive destruction of homes and healthcare facilities, many expectant mothers are unsure where or how they can safely deliver their babies. As, Khan, (2022) highlighted that services during flood has been the problematic in developing nations evidenced by the 2010 floods, where the health departments were deemed to be absent and all the equipment's were generally been lacked. Health systems in developing countries are particularly affected by floods, as they impede access to essential medical services (Shah et al., 2020; Winter et al., 2022). According to Latif (2019), Pakistan suffered losses of $80 billion from 1996 to 2016 due to weather-related disasters, affecting all four provinces. Families affected by floods in these areas often lack adequate shelter, sanitation, and health services (Salek et al., 2020). The pregnant women face severe challenges due to the lack of toilets, menstrual hygiene products, and safe spaces. It highlights that the services are greatly affected during floods in different cases like lack of availability of infrastructure, shortage of staffs as well as inappropriate use of the roads during floods. Research shows that almost 650,000 women who were seemed to be pregnant and 73,000 to be given birth within time were affected by flood in the province. In addition to the difficulties women face in giving birth, the destruction of roads and communication networks further hinders people's access to hospitals and clinics. So far, the literature revealed the challenges related to flood in contrast with health and damages to life. These barriers also impact women and girls seeking reproductive health services, including contraception (Salek et al., 2020).

Methods

For this study, data were systematically collected by reviewing 30 high-quality papers sourced from reputable online databases, including Google Scholar, Web of Science, Science

Direct, and Scopus, covering publications from 2003 to 2022. The selection prioritized recent, well-cited literature to ensure relevance and academic rigor. Inclusion criteria were strictly defined to encompass (a) peer-reviewed journal articles with a recognized impact factor, (b) scientifically validated reports on flood-related impacts from globally authoritative publishers, and (c) credible news articles providing supplementary context. Keyword-based filtering was applied, focusing on terms such as flood, climate, health, social impacts, developing countries, and floods in Pakistan, ensuring thematic alignment with the study's objectives. This methodological approach enhances the reliability and validity of the synthesized data, facilitating a robust evidence-based analysis.

Table-1: Literature Search Strategy

Component	Description
Sources of data gathered	Different databases including, science direct, MDPI, Sage open and google scholar as well as reports
Time Frame	2003–2022
Selection Criteria	- Peer-reviewed articles with impact factors - Scientific reports from recognized publishers - Reputable news articles
Keywords	Health concerns, Flood, Impacts, Climate change, Pakistan were used to get the results towards literature review
Inclusion Focus	Recent (last 10 years preferred), well-cited, relevant to flood impacts
Exclusion Criteria	Non-peer-reviewed sources, irrelevant scope, outdated studies (pre-2003)

Results and Discussion

Climate change has led to significant environmental disruptions, which in turn have caused severe health consequences. Flooding and extreme weather events worldwide contribute to a high burden of morbidity and mortality each year. In Pakistan, frequent floods are a direct result of the country's intense monsoon rains. Any nation would face immense challenges managing floods of the magnitude and scale seen in recent years in Pakistan. These floods have highlighted critical gaps in the country’s current capabilities, including inadequate warning systems, limited preparedness, poor disaster response, and the lack of comprehensive flood control measures. As a result, the country faces substantial health risks, with an increase in mortality rates following major floods. This study examined illness patterns to assess the vulnerability and health impacts of flooding.

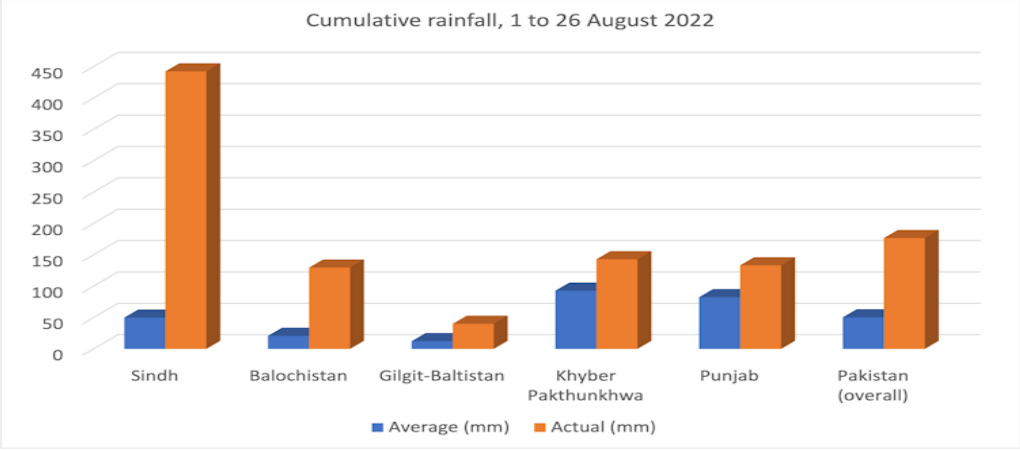

Figure 2: Rainfall in 2022

Source: (Zafar, 2022)

A systematic review of various reports and studies revealed that extreme weather events exacerbate health conditions, particularly in displaced and unsanitary populations, where disease outbreaks such as fever, dengue, and gastrointestinal illnesses are common. In addition, flood victims often have to deal with psychological distress and mental health challenges. Based on our comprehensive review of the literature, effective policies are essential to reduce flood-related morbidity and mortality.

Health Impacts of flood concerning, physical, psychological and mental health

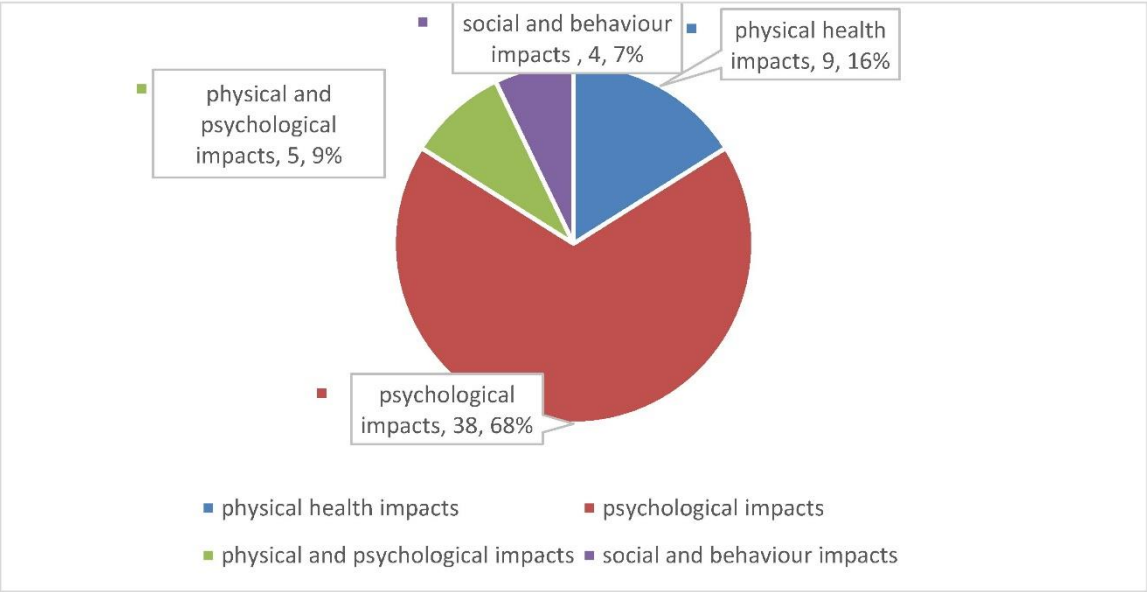

Figure 3: Health impacts of flood

Devastating floods have serious impacts on physical and mental health, often through the spread of bacteria, viruses, and other pathogens. These can include diseases such as diarrhea, cholera, dengue fever, and hepatitis E. Stagnant floodwaters create ideal conditions for mosquitoes and other disease vectors. In addition to infectious diseases, the effects of floods also include long-term health problems, such as chronic respiratory problems, anxiety, and depression. Displaced populations are particularly vulnerable, as they lack access to clean water, sanitation, and health care. Certain groups are more susceptible, such as the elderly, pregnant women, children, and those with pre-existing health conditions. Low-income communities living in informal settlements are particularly at risk, as they often live in flood-prone areas and lack basic infrastructure and services. Indigenous populations, migrant workers, and refugees are also more vulnerable due to limited access to health care and legal protections (Vighio, 2024). As highlighted in Figure-3 that the diverse concerns were observed related with health. Where, the psychological impacts have been found to be at greater extent because, most of the time local residents suffering from the floods have been in big hurdle psychologically. Where, the researchers found mind stress a big hurdle. The research findings highlight the need for large-scale recovery efforts to mitigate the health and economic impacts of floods in Pakistan. Floods are causing significant damage to infrastructure, reduced productivity, and increased health costs. This requires a focus on rebuilding jobs, agricultural systems, and private households. The restoration of public health facilities and the reconstruction of critical infrastructure such as roads, bridges, and schools are also important. To achieve these goals, a comprehensive framework for resilient recovery, rehabilitation, and reconstruction is essential.

Pakistan needs a transparent and inclusive approach, based on collaboration between the public and private sectors, academic institutions, think tanks, and the international community, where all are working towards a common goal. At the same time, disaster preparedness and response efforts should focus on protecting the most vulnerable populations. Implementing effective policies and interventions can help reduce the health impacts of floods and extreme weather events.

This study does not focus on specific interventions, and more research is needed to fill this gap. Future studies should examine different vulnerability factors, such as social, economic, and political aspects. In addition, research is needed on community-based interventions that can increase resilience and help reduce floods. Effective policies and strategies are essential to reduce the economic losses caused by floods and promote sustainable development. This review underscores the critical necessity for targeted interventions to mitigate flood-associated health risks and fatalities. Extreme flooding events disproportionately harm vulnerable populations, exacerbating existing health disparities. Proactive measures—including evidence-based policies and adaptive strategies—are essential to strengthen community resilience against climate-related disasters. Future studies should prioritize evaluating intervention efficacy and identifying key determinants of flood vulnerability. A collaborative, cross-sectoral response involving governments, NGOs, and private stakeholders is vital to effectively address the multifaceted health consequences of floods.

Management of flood disaster and the strategies for mitigating

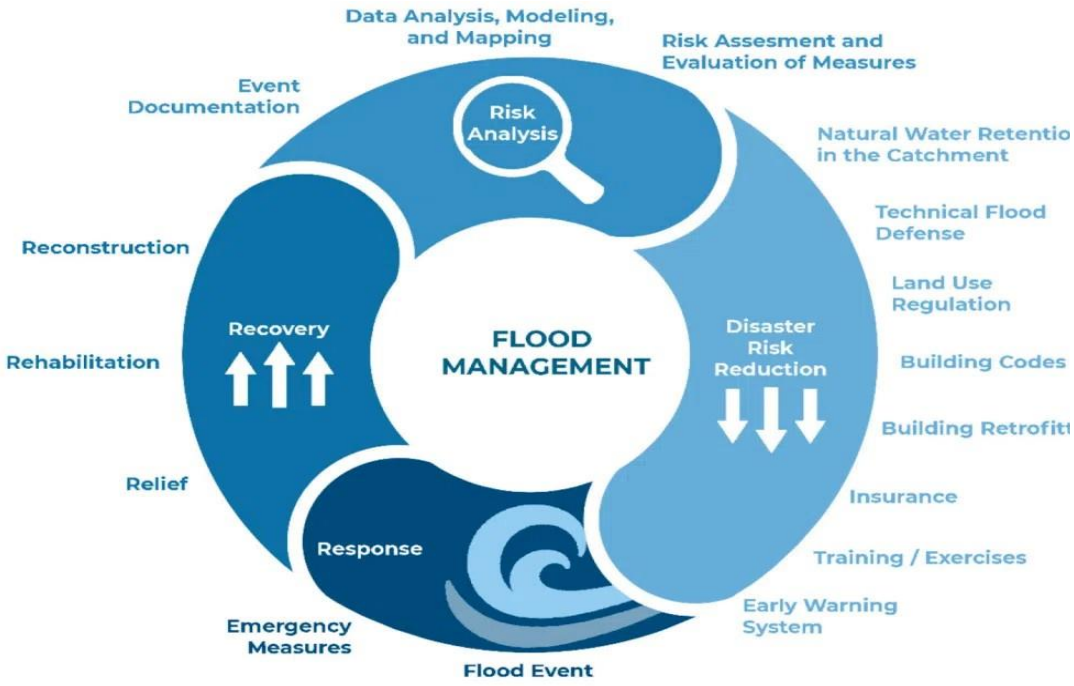

Figure 4: Flood management

Ensuring that temporary shelters meet the medical needs of displaced individuals requires a comprehensive, evidence-based approach that integrates chronic disease management, emergency preparedness, and equitable health service delivery. Maintaining records of essential medications for chronic illnesses ensures continuity of care, while clear emergency instructions enhance disaster response efficacy. Training first responders on the specific

needs of vulnerable groups—such as the elderly, children, and those with disabilities—promotes inclusive care, and proactive planning preserves basic health services during crises.

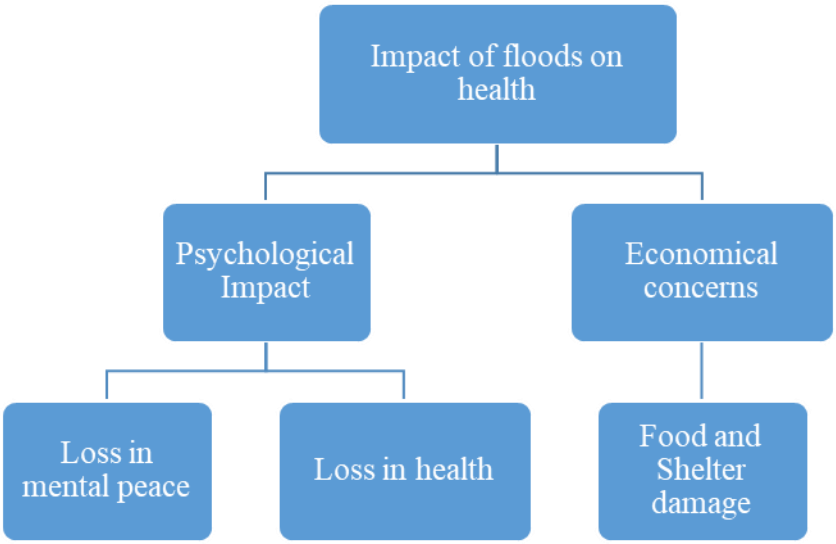

Figure 5: Researcher's investigation regarding the Flood impacts

A holistic health strategy should extend beyond acute treatment to include prevention, health promotion, and rehabilitation services, particularly for flood victims, to mitigate long-term health impacts. Researcher highlighted the investigation including the Flood and its impacts on health. Since, climate change was one of the big sector in flood conditions. While, it was observed that, local people were having flood as an impact on life contributing psychological stress, including loss of mental peace as well as danger to health, while, the loss in economic perspective were also deemed to be the higher as investigated from the literature review. Additionally, scaling up healthcare capacity, emergency shelters, and quarantine programs with a focus on differentiated needs ensures equitable access and reduces disparities in disaster response outcomes. This multi-faceted approach aligns with public health best practices, emphasizing resilience, equity, and sustainable recovery in humanitarian settings.

Conclusion

The study demonstrates that climate-amplified flooding in Pakistan creates cascading health impacts, disproportionately affecting vulnerable groups through injury risks, infectious disease outbreaks (particularly waterborne and vector-borne illnesses), and mental health deterioration. Systemic vulnerabilities—including fragile healthcare infrastructure, inadequate sanitation, and socioeconomic disparities—exacerbate these effects. Effective mitigation requires a multi-pronged strategy: (1) hardening health systems via mobile clinics and emergency medical stockpiles, (2) deploying predictive early-warning systems coupled with community education, (3) implementing targeted interventions like mental health programs and preventive care for high-risk demographics, and (4) integrating flood resilience into urban planning and ecosystem management. These findings underscore the necessity of cross-sectoral policies that bridge disaster response, public health, and climate adaptation, with particular urgency for low-resource settings facing intensifying hydrological hazards. Future efforts should prioritize context-specific solutions addressing both immediate health burdens and underlying determinants of vulnerability.

Strategies

Effective governance is critical for enhancing healthcare accessibility and disaster preparedness during flood events. Policymakers must prioritize equitable access to specialized services, including podiatric and psychological care, to address both physical and mental health needs in crisis situations. A well-organized, preemptive humanitarian framework can significantly diminish health inequities and safeguard displaced communities. Strategic fiscal interventions—such as targeted subsidies, tax relief programs, and economic incentives—represent viable policy tools for mitigating flood-related health consequences. However, successful implementation demands careful consideration of the socio-political dimensions influencing disaster governance. Furthermore, natural ecosystems serve as fundamental regulators of climatic systems and vital assets for community adaptation. Applying biodiversity conservation principles to ecosystem management can enhance societal resilience against climate-induced challenges, including recurrent flooding. Flood risk management strategies can help address gaps in disaster preparedness and response. Effective flood management depends on active participation, coordination, and engagement of the public and private sectors, with clear and enforceable regulations. It is important to create a balance of certainty and flexibility in regulations to respond to changing circumstances.

Limitations of the study

The research is based on the literature review reports, therefore, including primary data could provide more in-depth information in the field. Secondly, the focus of the research is dependent in Pakistan, while comparison with other developing nations could enhance more ground rooted knowledge in terms of learnings. Besides that the deep policies from developed nations could enhance more for the sustainable development.

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