
THE IMPACT OF FLOODING AS A SOURCE OF BIOLOGICAL THREAT ON HOSPITAL ADMITTANCE DEPARTMENTS

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Abstract: Flooding represents a significant natural disaster with far-reaching consequences, extending beyond material damages to encompass substantial risks to public health. Hospital admittance departments stand particularly vulnerable to the influx of individuals affected by flooding, which often introduces various biological threats. The objective of this article is to examine the potential risks and implications flooding poses on hospital admittance departments, with a focus on biological threats, employing an academic perspective.

By means of the descriptive and comparative methods were analyzed reports and records from various floods and the following spread of infectious diseases. The challenges are grouped, and preventive scenarios and measures are analyzed. Performed analyses have listed several significant challenges to the hospital admittance departments during and aftermath of occurred floods. They could be presented into following groups:

Biological Threats Arising from Flooding: Flooding events create conducive environments for the proliferation of diverse biological agents, including microorganisms, algae, that could provoke outbreak of infectious diseases. Water, laden with pollutants and pathogenic microorganisms, could also infiltrate hospital premises, including admittance departments, presenting significant challenges to healthcare institutions.

Flooding can lead to contamination of water sources with various pathogens such as bacteria, viruses, and parasites. These microorganisms may infiltrate hospital facilities through inundated water systems or contact with contaminated water bodies. In admittance departments, characterized by a continuous influx of patients, the risk of infection spread escalates significantly.

Toxic chemicals and pollutants In addition to microorganisms, flooding may result in the spillage of toxic chemicals and pollutants into the environment. Such substances can disseminate into water sources and reach hospital premises, posing health hazards to patients and medical staff alike.

Potential Scenarios and Preventive Measures Scenarios involving biological threats stemming from flooding in hospital admittance departments necessitate systematic planning and resource mobilization to mitigate infection transmission and safeguard patient health. Key measures include:

Implementation of Protective Systems: Hospitals should develop and deploy protective systems against flooding, including drainage infrastructure, purification facilities, and pollution control systems.

Development of Crisis Plans: Establishment of crisis plans to address biological threats, encompassing procedures for infection isolation, equipment disinfection, and staff training, is imperative.

Monitoring and Early Warning: Deployment of monitoring and early warning systems for water contamination can aid in promptly detecting potential health hazards and implementing necessary interventions.

Staff Training: Comprehensive training of medical personnel on recognizing symptoms of flood-related infections and adhering to appropriate protocols is essential.

In conclusion, the impact of flooding as a source of biological threat on hospital admittance departments demands a systemic and interdisciplinary approach. Healthcare institutions' preparedness to manage such crises is crucial for safeguarding patient and staff health and safety. Continuous development of strategies for prevention and mitigation of biological threats is paramount to addressing these challenges effectively in the future.

Keywords: Floods, Hospital disaster resilience, Biological threat, Hospital admittance department, Preventive measures

1. INTRODUCTION

Flooding disasters have become increasingly prevalent in the contemporary world, posing significant challenges to both human societies and ecosystems. This phenomenon is characterized by a myriad of interrelated factors spanning environmental, socio-economic, and anthropogenic domains. Understanding the genesis of this surge in flood disasters is imperative for crafting informed policies and interventions aimed at mitigating their adverse impacts. Some of the most significant factors that are traced as a sources for floods could be presented in the following groups:

Environmental Factors:

Environmental factors play a pivotal role in driving the increase in flooding disasters observed in the contemporary world. These factors encompass a spectrum of natural processes and human-induced alterations to the environment, collectively shaping the frequency, intensity, and spatial distribution of flood events. A detailed examination of environmental factors reveals several key drivers contributing to the escalation of flooding disasters:

- Climate change is perhaps the most prominent environmental factor influencing flooding disasters. The phenomenon of global warming is altering precipitation patterns, leading to an increase in the frequency and intensity of extreme weather events such as heavy rainfall and intense storms. Warmer atmospheric temperatures also enhance evaporation rates, resulting in heightened moisture content in the atmosphere and potentially more intense precipitation events when conditions are conducive to rainfall. Moreover, climate change-induced sea level rise exacerbates coastal flooding, threatening low-lying coastal communities with inundation and saltwater intrusion. (1-6)

- Changes in precipitation patterns, both in terms of total precipitation amounts and distribution over time and space, significantly influence flood risk. In many regions, there has been an observed increase in the frequency of intense rainfall events, characterized by short-duration, high-intensity precipitation. These events can overwhelm drainage systems, saturate soil, and rapidly increase surface runoff, leading to flash floods and urban inundation. Conversely, alterations in seasonal rainfall patterns, including prolonged dry spells followed by heavy rainfall, can exacerbate flood risks by priming landscapes for runoff when precipitation does occur. (7, 8)

- The melting of glaciers and reduction in snowpack due to rising temperatures contribute to increased flood risks in mountainous and high-latitude regions. Glacial meltwater serves as an important water source for rivers and streams, particularly during the warmer months when precipitation is scarce. However, accelerated glacial melting can lead to the abrupt release of large volumes of water, causing riverine floods downstream. Similarly, reductions in snowpack accumulation and earlier snowmelt timing alter the timing and magnitude of spring runoff, potentially exacerbating flood risks during the snowmelt season.

- Human-induced alterations to the natural landscape, such as deforestation and changes in land use patterns, significantly impact hydrological processes and increase vulnerability to flooding disasters. Deforestation diminishes the capacity of forests to intercept and absorb rainfall, leading to increased surface runoff and soil erosion. Moreover, the conversion of natural landscapes into urbanized or agricultural areas alters surface permeability, reducing infiltration rates and exacerbating runoff. Wetland degradation and the drainage of natural floodplains further exacerbate flood risks by removing important buffers and storage areas for excess water. (9-13)

- Anthropogenic modifications to riverine and coastal systems, such as channelization, levee construction, and the straightening of watercourses, can inadvertently exacerbate flood risks. These alterations disrupt natural flow regimes, increase flow velocities, and reduce the capacity of river channels to convey floodwaters. Additionally, the construction of dams and reservoirs can alter downstream hydrological patterns, potentially exacerbating flood risks in downstream areas during periods of heavy rainfall or dam failure events.

Socio-Economic Dynamics:

Socio-economic factors significantly influence the vulnerability and resilience of communities to flooding disasters. The impact of socio-economic dynamics on the increased frequency of floods is multifaceted, encompassing a range of interconnected factors that influence both exposure to flood hazards and vulnerability to their adverse impacts. Understanding these socio-economic dynamics is crucial for comprehensively addressing the escalating frequency of floods. Here, we delve into the various ways in which socio-economic factors contribute to this phenomenon:

- Urbanization and Population Growth: Rapid urbanization and population growth exert significant pressure on land use and development patterns, often resulting in the expansion of urban areas into flood-prone zones. The concentration of population and infrastructure in urban centers increases exposure to flood hazards, particularly in low-lying areas and riverine floodplains. Moreover, informal settlements and slums often develop in hazard-prone locations with inadequate infrastructure and services, exacerbating vulnerability to floods among marginalized communities.

- Inadequate Infrastructure and Urban Planning: In many regions, inadequate infrastructure and urban planning exacerbate vulnerability to floods. Poorly designed drainage systems, inadequate stormwater management infrastructure, and insufficient flood protection measures can amplify the impacts of heavy rainfall events by impeding the efficient conveyance of floodwaters and exacerbating inundation in urban areas. Moreover, the lack of zoning regulations and enforcement mechanisms may lead to uncontrolled development in flood-prone areas, further increasing exposure to flood risks.

- Socio-Economic Disparities: Socio-economic disparities play a significant role in shaping vulnerability to floods, with marginalized and economically disadvantaged communities often bearing a disproportionate burden of flood impacts. These communities may lack access to resources, information, and adaptive capacities necessary for

effective flood preparedness and response. Moreover, socio-economic inequalities may limit the ability of vulnerable populations to recover and rebuild following flood events, perpetuating cycles of poverty and vulnerability.

- **Land Use and Agricultural Practices:** Changes in land use patterns, including agricultural intensification and expansion, can influence hydrological processes and exacerbate flood risks. The conversion of natural landscapes into agricultural fields, particularly in floodplains and riparian zones, reduces the capacity of soils to absorb rainfall and increases surface runoff. Moreover, the use of agrochemicals and intensive farming practices may contribute to soil erosion and degradation, further exacerbating the impacts of flooding by reducing soil permeability and increasing sedimentation in watercourses.

- **Water Management and Resource Allocation:** The management of water resources, including the construction of dams, reservoirs, and irrigation systems, can influence flood frequency and intensity. While these infrastructure projects are often designed to provide water supply, hydroelectric power, and irrigation for agriculture, they can inadvertently alter natural hydrological processes and exacerbate flood risks downstream. Poorly coordinated water management practices may also lead to conflicts over water allocation and exacerbate vulnerability to floods among downstream communities.

- **Insurance and Risk Perception:** The availability and affordability of flood insurance influence risk perception and behavior among individuals and communities. In regions where flood insurance coverage is limited or unaffordable, property owners may be less motivated to implement flood mitigation measures or invest in resilient infrastructure, increasing vulnerability to flood hazards. Moreover, perceptions of flood risk may vary among different socio-economic groups, with marginalized communities often lacking access to information and resources necessary for effective risk management.

Anthropogenic Influences:

Human activities exert a profound influence on the frequency and magnitude of flooding disasters. Poorly planned urban development, improper land management practices, and the encroachment into flood-prone areas exacerbate vulnerability to inundation. Furthermore, the alteration of natural drainage systems, such as the construction of levees and dams, can inadvertently amplify flood risks by altering hydrological regimes and impeding natural floodplain functions. Moreover, while not directly anthropogenic in origin, human-induced climate change exacerbates flood-driven disasters by altering precipitation patterns, sea levels, and extreme weather events. The emission of greenhouse gases from human activities, such as burning fossil fuels and deforestation, has led to global warming and changes in the Earth's climate system.

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The objective of this article is to examine the potential risks and implications flooding poses on hospital admittance departments, with a focus on biological threats, employing an academic perspective.

2. MATERIALS AND METHODS

By means of the descriptive and comparative methods were analyzed reports and records from various floods and the following spread of infectious diseases. The challenges are grouped, and preventive scenarios and measures are analyzed.

3. RESULTS AND DISCUSSION

Performed analyses have listed several significant challenges to the hospital admittance departments during and aftermath of occurred floods. One of the main challenges is related to the type of diseases that are commonly reported in case of flood disaster. These diseases could have different origins. They are mainly associated to the so-called Biological Threats. Flooding poses not only immediate risks to human life and infrastructure but also gives rise to various biological threats that can have significant health implications. These threats arise from interactions between floodwaters, contaminants, and biological agents, leading to the proliferation of pathogens, toxins, and disease vectors. Understanding these biological threats is essential for implementing effective interventions and protective measures for mitigating the health risks associated with flooding. Some of the key biological threats arising from flooding, that have been noted during the performed analyses are listed in detail:

- The most common biological threat is associated with waterborne pathogens. Floodwaters often become contaminated with a variety of pathogens, including bacteria, viruses, and parasites, posing a significant risk of waterborne diseases. Pathogens such as *Escherichia coli* (*E. coli*), *Salmonella* spp., *Vibrio cholerae*, and norovirus can contaminate floodwaters through sewage overflow, agricultural runoff, and the release of animal waste. Ingestion or contact with contaminated water can lead to gastrointestinal illnesses, including diarrhea, vomiting, and stomach cramps. Additionally, floodwaters can contaminate drinking water sources, further exacerbating the risk of waterborne disease transmission.

- Another imminent health threat is related to the impact on the insects' populations that could spread vector-borne diseases. Flooding can create favorable conditions for the proliferation of disease vectors such as mosquitoes, ticks, and rodents, increasing the risk of vector-borne diseases. Stagnant floodwaters provide breeding grounds for mosquitoes, which can transmit diseases such as malaria, dengue fever, Zika virus, and West Nile virus. Moreover, flooding can displace rodents from their natural habitats, bringing them into closer contact with humans and increasing the risk of diseases such as leptospirosis, hantavirus infection, and rat-bite fever. Addressing vector-borne disease risks often requires vector control measures such as insecticide spraying, larval habitat elimination, and community education.

- Mold and fungal infections also increase within the flooded area. Flooding can lead to moisture accumulation and water intrusion in buildings, creating ideal conditions for mold and fungal growth. Mold spores present in the air and on surfaces can proliferate in damp environments, leading to mold infestations in flooded homes, schools, and workplaces. Exposure to mold spores and mycotoxins can trigger allergic reactions, respiratory symptoms, and exacerbate asthma and other respiratory conditions. Individuals with compromised immune systems, such as the elderly, young children, and individuals with chronic illnesses, are particularly susceptible to mold-related health effects. Mitigating mold-related health risks involves prompt drying and remediation of flooded structures, as well as adequate ventilation and moisture control measures.

Another challenge to the hospital staff is the consequences of the chemical contaminants that could be found and are frequently reported in case of floodings. Flood can result in the release and dispersal of chemical contaminants from industrial facilities, hazardous waste sites, and household chemicals, posing a risk of chemical exposure to humans and ecosystems. Industrial facilities, agricultural operations, and storage facilities may release toxic substances such as heavy metals, pesticides, and organic pollutants into floodwaters, soil, and sediments. Additionally, flooded homes and buildings may contain hazardous materials such as asbestos, lead-based paint, and volatile organic compounds (VOCs), which can pose health risks if not properly managed. Exposure to chemical contaminants can lead to a range of health effects, including respiratory problems, skin irritation, neurological disorders, and cancer. Remediation efforts following flooding events often involve hazardous waste cleanup, soil testing, and public health monitoring to assess and mitigate chemical exposure risks.

Psychological disorders are common among the patients coming to the admittance hospital departments. Flooding can result in population displacement, loss of livelihoods, and disruption of community infrastructure and services, leading to psychosocial stressors and mental health risks. Displaced individuals may face overcrowded living conditions, inadequate access to clean water and sanitation facilities, and heightened anxiety about their safety. Moreover, the loss of homes, possessions, and community ties can exacerbate feelings of grief, loss, and trauma among affected individuals and communities. Mental health support services, community resilience-building initiatives, and psychosocial support programs are essential components of post-flood recovery efforts, helping individuals and communities cope with the emotional and psychological impacts of flooding.

The second main challenge admission department manager must address is the possibility of possible department flooding. When a hospital's admission department is affected by flooding, it can pose numerous challenges that impact patient care, staff safety, and the overall functioning of the healthcare facility. Here, we delve into the detailed challenges that arise in hospital admission departments due to flooding:

- Associated with operational disruption: Flooding can disrupt the normal operations of the hospital admission department by damaging infrastructure, equipment, and essential systems. Floodwater can inundate the department, causing damage to walls, floors, ceilings, and electrical systems. This disruption may result in the temporary closure or relocation of the admission department, hindering the hospital's ability to admit and discharge patients efficiently.

- Related to the assurance of the patients' safety: The safety of patients is paramount during flooding events, as they may be vulnerable to injury, infection, or exacerbation of existing health conditions. Floodwater can pose physical hazards such as slippery floors, electrical hazards, and contaminated surfaces, increasing the risk of accidents and injuries. Additionally, patients with mobility issues or medical equipment dependency may face challenges accessing care or evacuating flooded areas, requiring specialized assistance and accommodations.

- Challenged coming patients' infection control: Flooding can introduce contaminants and pathogens into the hospital environment, posing risks of infection to patients, staff, and visitors. As mentioned above, contaminated floodwaters may contain bacteria, viruses, and other pathogens that can spread through contact with contaminated surfaces or inhalation of aerosolized particles. Hospital admission departments must implement stringent infection control measures, including disinfection protocols, personal protective equipment (PPE) use, and environmental monitoring, to prevent the transmission of waterborne diseases and nosocomial infections.

- Affected, jeopardized or disrupted communication and coordination: Effective communication and coordination are essential for managing the impact of flooding on hospital admission departments and ensuring continuity of patient care. Flood-related disruptions may impede communication channels, making it challenging for staff to

communicate critical information, coordinate response efforts, and access necessary resources. Clear lines of communication, backup communication systems, and established protocols for emergency response are essential for facilitating rapid decision-making and coordination during flooding events.

- Impeded patient flow and capacity management: Flooding can affect the hospital's ability to manage patient flow and maintain adequate capacity in the admission department and other clinical areas. Disruptions to admission processes, such as electronic health record (EHR) systems, patient registration, and bed management, may impede the timely admission, transfer, and discharge of patients. Additionally, the influx of flood-related injuries and illnesses may strain hospital resources and overwhelm capacity, necessitating contingency plans for surge capacity management and patient triage.

- Finally, significant is the challenge related to the staff safety and well-being assurance: Ensuring the safety and well-being of hospital staff is essential during flooding events, as they play a critical role in providing patient care and maintaining hospital operations. Floodwater poses physical and psychological risks to staff, including exposure to contaminants, stress, and fatigue. Adequate training, provision of PPE, and access to support services such as counseling and mental health resources are essential for safeguarding staff health and well-being during flood-related emergencies.

4. CONCLUSION

Based on the results of the performed analyses has to be noted that building resilience and preparedness in hospital admission departments is essential for mitigating the impact of flooding and ensuring continuity of operations.

This includes implementing flood-resistant building design, installing flood barriers and mitigation measures (drainage infrastructure, purification facilities, and pollution control systems), and maintaining backup systems for essential utilities such as power and water supply for increase of the static resilience.

Key measures for increasing the operative resilience include:

- Development of Crisis Plans: Establishment of crisis plans to address biological threats, encompassing procedures for infection isolation, equipment disinfection, and staff training, is imperative.

- Monitoring and Early Warning: Deployment of monitoring and early warning systems for water contamination can aid in promptly detecting potential health hazards and implementing necessary interventions.

- Staff Training: Comprehensive training, including regular drills and training exercises, of medical personnel on recognizing symptoms of flood-related infections and adhering to appropriate protocols is also essential for ensuring staff readiness and response effectiveness during flooding events.

REFERENCES

- Alifu, H., Hirabayashi, Y., Imada, Y., & Shiogama, H. (2022). Enhancement of river flooding due to global warming. *Scientific Reports*, 12(1), 20687.
- Bathurst, J. C., Fahey, B., Iroumé, A., & Jones, J. (2020). Forests and floods: using field evidence to reconcile analysis methods. *Hydrological Processes*, 34(15), 3295-3310.
- Buechel, M., Slater, L., & Dadson, S. (2022). Hydrological impact of widespread afforestation in Great Britain using a large ensemble of modelled scenarios. *Communications Earth & Environment*, 3(1), 6.
- Chagas, V. B., Chaffe, P. L., & Blöschl, G. (2022). Climate and land management accelerate the Brazilian water cycle. *Nature Communications*, 13(1), 5136.
- Cooper, M. M., Patil, S. D., Nisbet, T. R., Thomas, H., Smith, A. R., & McDonald, M. A. (2021). Role of forested land for natural flood management in the UK: A review. *Wiley interdisciplinary reviews: Water*, 8(5), e1541.
- Gudmundsson, L., Boulange, J., Do, H. X., et al. (2021). Globally observed trends in mean and extreme river flow attributed to climate change. *Science*, 371(6534), 1159-1162.
- Li, K., Wang, G., Gao, J., Guo, L., Li, J., & Guan, M. (2024). The rainfall threshold of forest cover for regulating extreme floods in mountainous catchments. *Catena*, 236, 107707.
- Noto, L. V., Cipolla, G., Francipane, A., & Pumo, D. (2023). Climate change in the mediterranean basin (part I): Induced alterations on climate forcings and hydrological processes. *Water Resources Management*, 37(6), 2287-2305.
- Parmesan, C., Morecroft, M. D., & Trisurat, Y. (2022). Climate change 2022: Impacts, adaptation and vulnerability (Doctoral dissertation, GIEC).
- Seneviratne, S. I., Zhang, X., Adnan, M., et al. (2021). Weather and climate extreme events in a changing climate (Chapter 11).
- Slater, L. J., Anderson, B., Buechel, M., Dadson, S., Han, S., Harrigan, S., ... & Wilby, R. L. (2021). Nonstationary weather and water extremes: a review of methods for their detection, attribution, and management. *Hydrology and Earth System Sciences*, 25(7), 3897-3935.

- Wasko, C., Nathan, R., Stein, L., & O'Shea, D. (2021). Evidence of shorter more extreme rainfalls and increased flood variability under climate change. *Journal of Hydrology*, 603, 126994.
- Xiao, L., Robinson, M., & O'Connor, M. (2022). Woodland's role in natural flood management: Evidence from catchment studies in Britain and Ireland. *Science of the Total Environment*, 813, 151877.