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Health Consequences Management in a Multi-Hazard Context: A Systematic Review of the Coincidence of Flood and the COVID-19 Pandemic

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Systematic Review

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Abstract

Objectives: The co-occurring flood and coronavirus disease (COVID-19) increase the consequences for health and life. This study examined the strategies to manage the health consequences of the co-occurring flood and COVID-19, with a specific focus on these 2 challenges.

Methods: This review included all the studies published in peer-reviewed journals between January 1980 and June 2021. Several electronic databases were searched, including Scopus, Web of Science, and PubMed. Mixed Methods Appraisal Tools (MMT), version 2018, assessed the articles retrieved through a comprehensive and systematic literature search. Descriptive and thematic analyses were carried out to derive strategies for managing the health consequences of the simultaneous flood and COVID-19.

Results: Among 4271 identified articles, 10 were eligible for inclusion. In total, 199 strategies were identified in this review for managing the multi-hazard health consequences of flooding and COVID-19, which were classified into 9 categories and 25 subcategories. The categories included policy making and decision making, coordination, risk communication, logistics, planning, preparedness measures, response measures, social and humanitarian support, and actions of local communities and non-governmental organizations.

Conclusions: Managing a multi-hazard and reducing its health consequences requires various actions. Flood management must be needed, and flood-affected people and their health should be protected.

While the world was facing difficulties in managing the coronavirus disease (COVID-19) pandemic, many cities and countries suffered from floods during this period.[1] Flooding during the COVID-19 pandemic, as a multi-hazard, challenged the resilience of communities and health systems as well as intensified the severity of health consequences of COVID-19.[2] A multi-hazard is a combination of 2 or more hazards from different sources happening randomly and simultaneously with a destructive force.[3] Due to flooding, the COVID-19 pandemic management[1] and the flood-affected communities' efforts to reduce the spread of the pandemic faced several challenges.[4] Cyclone Harold in the Pacific countries (in April 2020), the flood of Manitoba and Ottawa in Canada (in August 2020), and the flood of Bangladesh (during June and July 2020) occurring at the same time as the COVID-19 pandemic are examples of such cases.[3–5] Floods and tornadoes in Bangladesh (at the end of May 2020) doubled the number of COVID-19 instances to more than 110 000. In addition, Cyclone Amphan killed 26 people and displaced 2.4 million people from their homes in Bangladesh, significantly increasing the COVID-19 cases among the cyclone-affected communities.[6]

Severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) is an emerging respiratory virus responsible for the pandemic of the ongoing COVID-19.[7] This syndrome can lead to severe respiratory complications, such as acute respiratory distress syndrome, acute respiratory injury, and severe pneumonia in patients.[8] On the other hand, floods, as the most common natural disasters in the world,[9–12] lead to infectious diseases among flood survivors and refugees,[13] as well as increase the risk of chronic respiratory diseases and the death of chronic respiratory patients. In addition, the aggravation of non-communicable diseases due to public health problems and the spread of other communicable diseases after the flood can be mentioned.[14]

Lim et al. stated that one of the problems of the refugees in the camps was the spread of respiratory diseases due to floods and tsunamis.[15] Upper respiratory infections are the most common infectious disease after floods, along with flu-like symptoms,[16] and severe pneumonia.[13] Moreover, studies showed that the number of visits and admissions of patients due to respiratory diseases increased after floods.[14]

Effectively managing floods alongside the challenges posed by the COVID-19 pandemic is a formidable task. The actions taken to control 1 crisis may inadvertently exacerbate other issues.[5] Mishandling flood responses during the pandemic have the potential to accelerate the spread of the COVID-19 virus, leading to heightened consequences. Consequently, there is a risk of increased human fatalities and amplified societal damages.[5] Moreover, emergency flood responses, such as evacuations, may encounter complexities due to COVID-19 measures like social distancing and isolation, hindering their implementation. Indeed, stringent COVID-19 regulations might render flood risk management responses insufficient to mitigate the overall damage adequately.[17]

The combined effects of the flood and the COVID-19 pandemic led to an increased chance of disease transmission in vulnerable populations.[6] There are various reasons for increasing the risk of transmission of infectious diseases, including respiratory diseases after floods, such as severe damage to vital infrastructure, displacement of populations, injury and damage to water supply sources, and pollution of facilities and drinking water sources.[16] In addition, flood victims may be exposed to polluted water, crowded living conditions, and severe traumatic injuries. Residential areas' heating and ventilation systems are also damaged or submerged in floods, becoming a health hazard and a means of transmitting microorganisms and increasing respiratory and pulmonary complications after floods.[15]

Floods and tornadoes in Bangladesh led to the complete or partial destruction of 200 000 houses and intensified the socioeconomic and health effects caused by the COVID-19 pandemic in Bangladesh.[6] Inadequate response to floods during the COVID-19 pandemic also increased the spread of COVID-19. Further, the coincidence of the flood and COVID-19 increased the economic and social conditions of the communities under significant pressure,[4] which led to the loss of human lives and financial losses in the future.[4] Therefore, it is necessary to adopt new approaches to reduce the health consequences, damages, and casualties caused by the coexistence of COVID-19 and floods. Moreover, appropriate and effective response systems should be developed to strengthen health care services in the multi-hazards context. International policies in line with sustainable development to reduce environmental risks require research on multi-hazards as a part of disaster management programs in disaster-prone areas.[18] Therefore, in line with the aforementioned policies, this study will attempt to identify the scientific and practical strategies for managing the simultaneous flood and COVID-19 by systematically reviewing and synthesizing the recent evidence.

Research Objectives and Questions

This study aimed to investigate and categorize strategies for managing the health consequences of the simultaneous flood and COVID-19, and other emerging diseases, in order to provide a basis for managing and reducing the health consequences of multi-hazards. The review will try to answer the following questions:

- What are the strategies for managing the health consequences of multi-hazard, such as simultaneous floods and COVID-19?
- How has the management of health consequences been conducted of simultaneous disasters in communities affected by floods and COVID-19?
- What is the role of the health sector in different phases of multi-hazard management, such as flood and COVID-19, including prevention, preparedness, response, and recovery?
- What is the role of other responsible organizations and the affected community in different phases of multi-hazard management, such as flood and COVID-19, including prevention, preparedness, response, and recovery?

Materials and Methods

We followed the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) 2020 guidelines[19] for the study and used the Mixed Method Appraisal Tool (MMAT) to assess the methodological quality of the eligible articles.[20]

Inclusion and Exclusion Criteria

The included studies and documents were articles and reports for managing health consequences caused by the coexistence of flood risk and COVID-19 or the coexistence of flood and other emerging diseases that were within the scope of the research question of this study. We reviewed the articles and documents published from January 1980. Studies that did not investigate these types of strategies and investigated other outcomes were excluded. Documents whose full text was unavailable and were published in non-academic publications were also excluded. In addition, studies published in other languages, except in English, were excluded from the study.

Databases and Search Strategies

This systematic review focused on the publications and documents related to strategies for managing the health consequences of simultaneous floods and COVID-19, and other emerging diseases worldwide. Several government, non-government, and academic electronic sources as well as several electronic databases, including Scopus, Web of Science, and PubMed, were searched for the relevant literature from January 1980 to June 11, 2021. Google Scholar articles were also searched manually. We also used the articles' reference lists and the snowball method to find relevant studies.

We developed the search term using Medline indexing, Embase, and Medical Subject Headings (MESH) to identify as many articles as possible. The search syntax was written using keywords and synonyms that were searched in the title, abstract, or keyword sections of the databases. The keywords selected were the same as those used when searching websites and databases. The summarized form of the search strategy was as follows:

(*Flood*) AND (Health OR Disease) AND (COVID-19 OR Pandem* OR Emerging epidemics)

Study Selection

One researcher (AY) screened the titles and abstracts of the found articles to find related articles using end-note software. Then, 2 independent researchers (AY and MSB) reviewed the full text of the selected articles. In disagreements between the 2 researchers,

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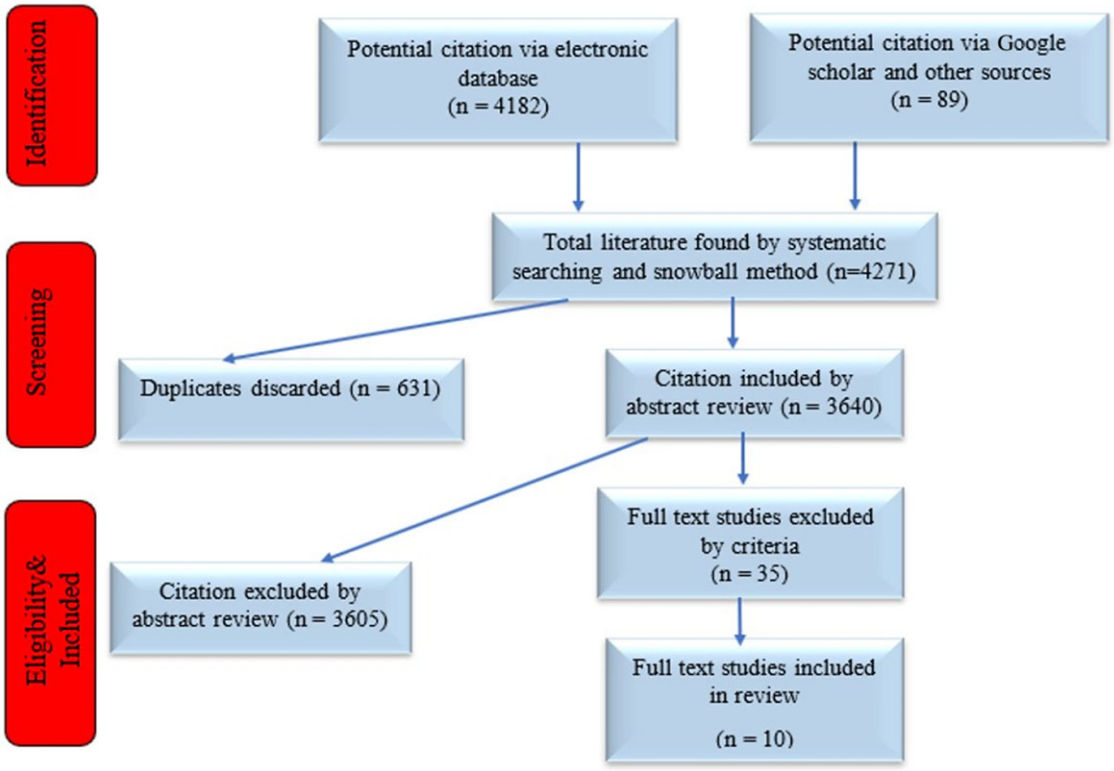

Figure 1. Flow diagram of the search and selection of papers.

the third researcher (MEM) resolved the issues and helped them make the best choices. Figure 1 shows the process of reviewing and selecting articles.

Quality Appraisal

The quality of the finally included articles was evaluated using the Mixed Methods Appraisal Tool (MMAT), and the articles were classified into 3 groups: low, medium, and high.[20] The articles in the low group were excluded from the study. The MMAT is reliable for appraising the methodological quality of quantitative, qualitative, and mixed-methods studies, including randomized controlled trials, nonrandomized trials, and descriptive quantitative studies.[21]

Data Extraction and Analysis

The extracted data were recorded in 2 separate forms. The first form included the general characteristics of the article, such as the article's authors, study location, study objectives, publication date, methodology, and type of article (Table 1). The second form was related to extracting categories and subcategories for classifying strategies and managing the health consequences of the simultaneous flood and COVID-19, as well as other emerging diseases in the world (Table 2). Then, descriptive and thematic analyses were performed for selected articles and texts. Thematic analysis is used as a systematic method for data analysis to identify, understand, analyze, and report topics in a set of related data.[10] After extracting descriptive data, the authors coded the strategies for managing the health consequences of the simultaneous flood and COVID-19, and other emerging diseases worldwide. Then, similar codes were grouped, and the grouped findings were analyzed to categorize these solutions. The accuracy and completeness of the data extracted by the research team were discussed in a group.

Results

In total, 4271 articles and documents were identified through the initial literature search. After removing 631 duplicate articles, the remaining 3640 article titles and abstracts were screened. Then, the full text of 35 articles was reviewed after removing 3605 articles based on the inclusion and exclusion criteria. Finally,10 eligible studies were included in the research and analyzed. Figure 1 provides a quick overview of how the data were collected. The eligible articles were evaluated using the MMAT tool and classified as low, medium, and high methodological quality. Any study with serious methodological concerns and low quality was excluded (see Table 1).

Descriptive Analysis

Most of the included articles (9 out of 10) were related to areas that experienced flooding during the COVID-19 pandemic. Among them, 1.5 were related to the Asian continent, and 30% were related to the American continent. In addition, Indonesia had the highest number of studies (20%). Most studies (40%) examined the simultaneity of floods and COVID-19 and the measures taken by reviewing scientific literature. About 30% of the included studies were a report or a case report, which analyzed the actions taken and described the simultaneous events of the flood and COVID-19. A study also qualitatively analyzed the vulnerability and preparedness of society during the accompanying flood and COVID-19. The specifications of the included articles are shown in Table 1.

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Table 1. Descriptive analysis of included papers in the systematic review of health consequences management of multi-hazard, including flood and COVID-19

SI	Title	First author	Year	Country	Type of hazards	Type of study	Study objective	Appraised quality
1	*Vector-control response in a post-flood disaster setting, Honiara, Solomon Islands, 2014*	Matthew Shortus	2016	Solomon Islands	Flash flood and vector-borne disease	Case report	Assessment of the risk of vector-borne diseases after floods in in the affected areas of Honiara and Guadalcanal Province, and description of the application of rapid response interventions to reduce the level of exposure of those living in evacuation centers	Moderate
2	*Impacts of flood disasters in Nigeria: a critical evaluation of health implications and management*	Caroline C. Olanrewaju	2019	Nigeria	Flood and epidemic threat	Mixed (review, qualitative and quantitative)	Critical evaluation of health interventions and management of floods in Nigeria, reviews past and present impacts of flood disasters on human health, reviews the history of flood management in Nigeria, and critical analyses of the government's response to infectious diseases and waterborne diseases in the aftermath of floods	High
3	*COVID-19, storms, and floods: impacts of Tropical Storm Cristobal in the western sector of the Yucatan Peninsula, Mexico*	Oscar Frausto-Martínez	2019	Mexico	COVID-19 and flood	Case report	Analysis of the effects of Hurricane Cristobal's floods on Mayan communities in western Yucatan Peninsula during the COVID-19 pandemic	Moderate
4	*Managing disasters amid COVID-19 pandemic: approaches of response to flood disasters*	Mikio Ishiwatari	2020	Japan	Flood and COVID-19	Review	Proposing policies and approaches for managing simultaneous occurrence of floods and COVID-19 outbreaks	High
5	*Floods and the COVID-19 pandemic—a new double hazard problem*	Slobodan P. Simonovic	2020	Canada	Flood and COVID-19	Overview	Evaluating the challenges of concurrent floods and COVID-19 as a multi-hazard issue and providing guidelines for effectively addressing these challenges	High
6	*Responding simultaneously to flood and COVID-19 in Iran*	Farin Fatemi	2021	Iran	Flood and COVID-19	Letter to the Editor	Presenting the most important practical measures of the health system for better management of concurrent floods and COVID-19 through a scientific review of texts and expert panels	Moderate
7	*Superposed natural hazards and pandemics: breaking dams, floods, and COVID-19*	Mohammad Amin Hariri-Ardebili	2021	United States	Floods during dam break and COVID-19	Review	Examining the risks and consequences of the simultaneous occurrence of natural disasters and contagious diseases outbreak: concurrent flooding caused by dam failure and COVID-19	High
8	*Monsoon, floods and COVID-19: building community resilience in Bangladesh*	Yoko Okura	2020	Bangladesh	Monsoon, floods, and COVID-19	Report	Reviewing and proposing solutions to governments, donors, and communities for better preparedness and enhanced resilience to compound risks arising from the simultaneous occurrence of COVID-19 during the rainy season	Moderate
9	*Community preparedness toward flood during COVID-19 pandemic at Pekalongan City and Regency*	Gardena Smoro Laksmi	2020	Indonesia	Flood during COVID-19 pandemic	Review	Review of different countries' actions for managing natural disasters during the COVID-19 pandemic	High
10	*Assessment of vulnerability and community preparedness against flood disaster during COVID-19 pandemic period in SemarangCity*	Ananto Aji	2021	Indonesia	Flood disaster during COVID-19 pandemic	Qualitative study	Evaluating community vulnerability and preparedness against flood disasters during the COVID-19 pandemic in the city of Semarang	High

Table 2. Reviewed categories and subcategories of multi-hazard health management strategies and approaches

Category	Subcategory	Code: strategies and approaches
Policy and decision making	Policies and approaches	• High commitment of the government to protect human life, ensure social justice, and equal access to help • Integrated policy, risk management approach, and the cycle of prevention, preparation, response, and recovery with new policies of human security and approaches to dealing with multiple hazards • Systems approach combined with dynamic resilience, moving from disaster vulnerability to disaster resilience, and resilience approach in response to floods or a pandemic • Reinforcing resilience as a new development paradigm, strengthening disaster resilience, achieving sustainable development, and integrating resilience into sustainable development • Raising leaders' awareness of DRR in the pandemic • Participation of scientists in policy-making • Strengthen community-wide coordination mechanisms to support preparedness, including health, Red Crescent, transportation, travel, security, and other first responders to disaster • Strengthening global solidarity and international cooperation to face these successive challenges • Use of interdisciplinary knowledge and all related and required sciences for disaster management based on integrated cycle
	Instructions	• Development of disaster management policies and guidelines in the country
	Decision making and prioritization	• Transparent hierarchical decisions, participation of scientists in decision-making processes, and the priority of natural disaster management staff • Protecting disaster risk management stakeholders from the threat of COVID-19 • Support of government organizations to local communities from 3 aspects, including financial, technical, and information needed
Coordination	Inter- and intra-departmental coordination	• Cooperation and coordination between stakeholders, coordination in service delivery, clarity of roles and responsibilities among individuals in disasters, engaging local organizations and communities, coordination with different departments, especially water and sanitation, and multi-sector coordination • Coordination with all related organizations, including health, for disaster management planning simultaneously with COVID-19 and coordination between the local community and stakeholders • Promoting coordination and cooperation in military and civilian affairs
Risk communication	Risk assessment and information risk management	• Providing a risk map, risk assessment, rapid health assessment, activating the surveillance system, and data collection for the surveillance system • Considering food security indicators in community assessment
	Communication	• Risk communication with scientific knowledge, transparent dissemination of information, prevention of rumors and misinformation, communication, education, and message transmission by community leaders • Information dissemination through religious leaders, and teachers for strengthening awareness, information dissemination via leaflets and microphone announcements, use of Information, Education, and Communication (IEC) materials • Ensuring timely access of people to information and understanding the necessary measures for prevention, the possibility of calling people in emergency situations, making it possible to contact people in emergency situations, disaster simulation using artificial conditions to increase risk perception
	Training and information dissemination	• Information and awareness to prepare for a flood, informing the people and society, improving the level of health awareness such as hygiene and social distancing in local communities • Intensive training in public health actions, including hand hygiene, respiratory etiquette, and social distancing by health care personnel in the provinces receiving flood warnings • Educating people about self-protection and using personal protective equipment (PPE) when operating flooded and contaminated equipment, informing the community about how to prevent the transmission of COVID-19 • Information, education, and training, providing the necessary information and educational materials to promote awareness and prevention
Logistic	Infrastructure and logistic	• Providing the necessary equipment and technologies, preparation and installation of an early warning and evacuation system, infrastructural and logistic preparation • Provision of early warning systems in the prevention phase, providing a free weather warning application for installation on mobile devices
	Sheltering	• Construction of additional evacuation sites, preparation of evacuation sites according to health protocols and risk assessment, seeking or considering building temporary evacuation sites to prevent crowding and isolate people with suspected symptoms • Establishing emergency camps or temporary accommodation for displaced or homeless populations who have to leave their homes, going to friends' houses instead of evacuation centers • Provide a special place for people with disabilities and the older adults
	Medical and pharmaceutical equipment	• Provision of necessary drugs, including anti-epileptic drugs and those for pulmonary embolism • Provision of essential items such as hand soap, water, and hygiene kits at evacuation sites • Providing the emergency health needs of flood-affected people with special attention to vulnerable groups, especially the older adults, women, and children
	Budget	• Financial management of disaster, providing financial and material needs and resources • Preventing economic and financial catastrophe by implementing DRR measures under COVID-19, Insurance of people against floods

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Table 2. (*Continued*)

Category	Subcategory	Code: strategies and approaches
	Supply and distribution of resources	• Providing more human needs than before COVID-19, allocation of resources based on priorities in evacuation and shelter centers, determining the distribution location and how patients can access outpatient drugs • Staff training on how to deliver and distribute drugs and weekly distribution of sufficient quantities of hygiene items such as masks, soap, and waterless disinfectants (ie, solutions containing alcohol) to disinfect hands and surfaces among the flood-affected people • Protection of scarce medical resources against the effects of disasters, resource distribution quality, and distribution of relief goods for flood-affected people through the communication of government organizations, non-governmental organizations, and regional and international organizations • Availability and urgency of personnel and facilities at the scene of the accident
Planning	Preparedness plan	• National contingency plan, contingency response plan • A national disaster management plan that enables the participation and cooperation of all stakeholders with a holistic approach, clarity of the role and responsibilities among different levels of government, participants, and organizations in the program • Flexibility in plan, having a surveillance system, and command structure • Having plans and scenarios, including scenarios as a tool for investigating a range of possible future outcomes and providing basic input into the quantitative resilience assessment process, a multi-hazard emergency management plan, a flexible plan, emergency action plans (EAPs), contingency plans for flood threats during a pandemic, providing an emergency evacuation guide for areas affected by floods during COVID-19 pandemic, and the preparation of an emergency action plan or for emergencies by the International Committee of the Red Cross (ICRC) for preparedness. These plans are designed based on the scenario of events with a high probability of occurrence.
	Response plans	• Epidemic evacuation plan, primary health care plan in flood • Operational and response protocols, adaptation of action protocols • Guidance on considering COVID-19 in disaster management planning, livelihood programs planning • Disaster response plan during a pandemic, emergency response plan, disaster risk assessment plan • Guide for prevention, preparation, and management of emergencies in the context of COVID-19, excessive COVID-19 protocol
Preparedness measures	Community preparedness	• Disaster preparedness and mitigation activities, preparing communities for compound risks of COVID-19 and the monsoon season, such as building additional evacuation centers • Improving flood preparedness during the COVID-19 pandemic, community disaster preparedness during a pandemic: having a “go kit” ready for emergencies with flashlights, water bottles, face masks, latex gloves, medications, hand sanitizers, soap, disinfectant wipes, thermometers, etc. • Evacuation exercise, a key activity in preparing for emergency situations due to the occurrence of multiple hazards at the same time
	Organizational readiness	• The readiness of related organizations and people for timely response • Preparing a list of people and organizations with experience in order to call and connect with them when needed, for example, by group email
Response operation	Notification and warning	• Declaration of emergency to the entire area affected by floods and storms • Warning: having an early warning system • Activation: activating the early warning system of infectious diseases
	Management and command	• Implementation of DRR strategies and preventive measures to protect areas affected by hydrological/water-related disasters from becoming new epicenters of the pandemic, implementation of precautionary and control measures, emergency and strategic interventions, and development of alternative solutions • Timely intervention, timely control of outbreaks and epidemics, evaluation and assessment of disaster damages, analysis of the effectiveness of operations • Employing forces and all necessary equipment for the response, service availability, and quality services • Participation of all stakeholders in disaster management; participation of scientists in health, water, and disaster management; active participation of all stakeholders • Considering the total affected area and the geographical location • Prioritization of evacuation centers based on the assessment of the risk of the spread of COVID-19 and floods, prioritizing disaster management staff
	Rescue and relief	• Rescue and relief activities, appropriate defense and response, ensuring access to flood-affected areas, and dealing with floods as a team with as few people as possible • Installation of physical barriers with sand by workers while eliminating the observance of a safe distance of 2 meters, simultaneous observance of social distance by employees and volunteers involved in the flood, observance of social distance, and restrictions of COVID-19 in dealing with floods • Protection of disaster evacuees against the threat of COVID-19, ensuring the safety of human lives in evacuation centers and protecting COVID-19 patients from the threat of disasters • Applying new policies and approaches needed

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Table 2. (*Continued*)

Category	Subcategory	Code: strategies and approaches
	Health department's response	• Provision of health services: providing health services, especially in rural areas • Water and sanitation: supply of water and sanitation (based on Sphere standards), control and supervision of shared bathrooms, decontamination of surfaces with water and detergents, and using properly designed toilets to prevent contamination of underground water resources • COVID-19 prevention and management: compliance with health protocols to prevent the increase in cases of COVID-19, maintaining social distance during the process of evacuating people from areas at risk and in temporary residences, implementation of health measures in flood-affected areas to prevent the increase of COVID-19 cases, compliance with social distancing and restrictions of COVID-19, staying at home as long as possible to avoid overcrowding in evacuation centers, taking protective measures against COVID-19 (such as wearing masks in evacuation centers), increasing flood disaster management measures in health centers with sick or infected people, early diagnosis of COVID-19 patients in the displaced population, isolation of patients by establishing a care system in emergency and temporary shelter camps, controlling critical points for the management of waste infected with the new coronavirus in medical centers or field hospitals, access to counseling and psychological support for flood victims (especially for families who have lost members due to COVID-19), providing clean water, personal hygiene, and social hygiene sustainably during and after disasters, employing people and workers while complying with the protocols of COVID-19, and compliance with social distance, ensuring that each activity involves a maximum of 5 people. • Evacuation and sheltering measures: reduction in shelter capacity, implementation of cleaning and disinfection protocols, activation of community health supervision brigades, provision of hygiene supplies, water, and electricity, as well as nurses and alert doctors • Waste management: throwing away contaminated food, even canned food
Social and humanitarian support	Humanitarian assistance and international support	• Applying COVID-19 control measures to international aid, providing international aid, and implementing humanitarian assistance • Reducing restrictions on international aid shipments and reducing the restrictions of COVID-19 on the entry of international aid and shipments • Observing and implementing COVID-19 control measures for international aid, such as disinfecting shipments
	Social support	• Focusing on vulnerable groups, providing special attention to the older adults, and supporting highly vulnerable populations • Increasing food and financial support, especially for vulnerable groups, during COVID-19 and before the occurrence of disasters such as floods • Implementation of measures to prevent sexual violence in camps, including increasing the number of online support and counseling hotlines and promoting them through the media • Protection of workers and volunteers
Local communities and NGOs	Local communities	• Local coordination, engaging local communities, fostering a 2-way trust between individuals and society/government • Encouraging individuals to go to relatives' homes instead of evacuation centers and avoid crowds at evacuation centers • Observing and continually following health protocols within the community during the evacuation, including wearing masks, practicing social distancing at evacuation centers, and avoiding group activities
	NGOs	• Strengthening the capacity of UDMC[a] or disaster management committees, including through personnel and financial support • Involving local organizations and communities
	Volunteers	• Enlisting volunteers from areas that are unaffected by the flood • Getting help from volunteers for cleaning and rebuilding flood-damaged houses • Preparing volunteers to assist COVID-19 patients • Use of PPE by workers and volunteers during evacuation

[a]Union Disaster Management Committee (UDMC).

Thematic Analysis

In total, 9 categories, 25 subcategories, and 199 solutions were extracted from the 10 articles. Many solutions or strategies were mentioned commonly in all studies, such as planning, training, information, evaluation, quick evacuation, quick warning system, and coordination. For example, the planning solution and different types of programs were mentioned 26 times in the planning category, and the evacuation solution was mentioned 24 times as the most repeated solution in the reviewed articles. Some studies specifically mentioned the management and attraction of humanitarian and international aid.[13] The flood insurance solution was mentioned only once in the reviewed studies.[22] In addition, most solutions were related to the response operation category, with 51 consisting of 4 essential subcategories: warning, management and command, rescue and relief, and health response. The logistics category was in second place with 28 solutions and 5 subcategories. In the subcategory level, health sector management had the most solutions (19).

Discussion

To the best of the authors' knowledge, this is the first systemic review that summarizes and classifies the strategies for managing the health consequences caused by the coexistence of flood and COVID-19. We found a comprehensive list of strategies by

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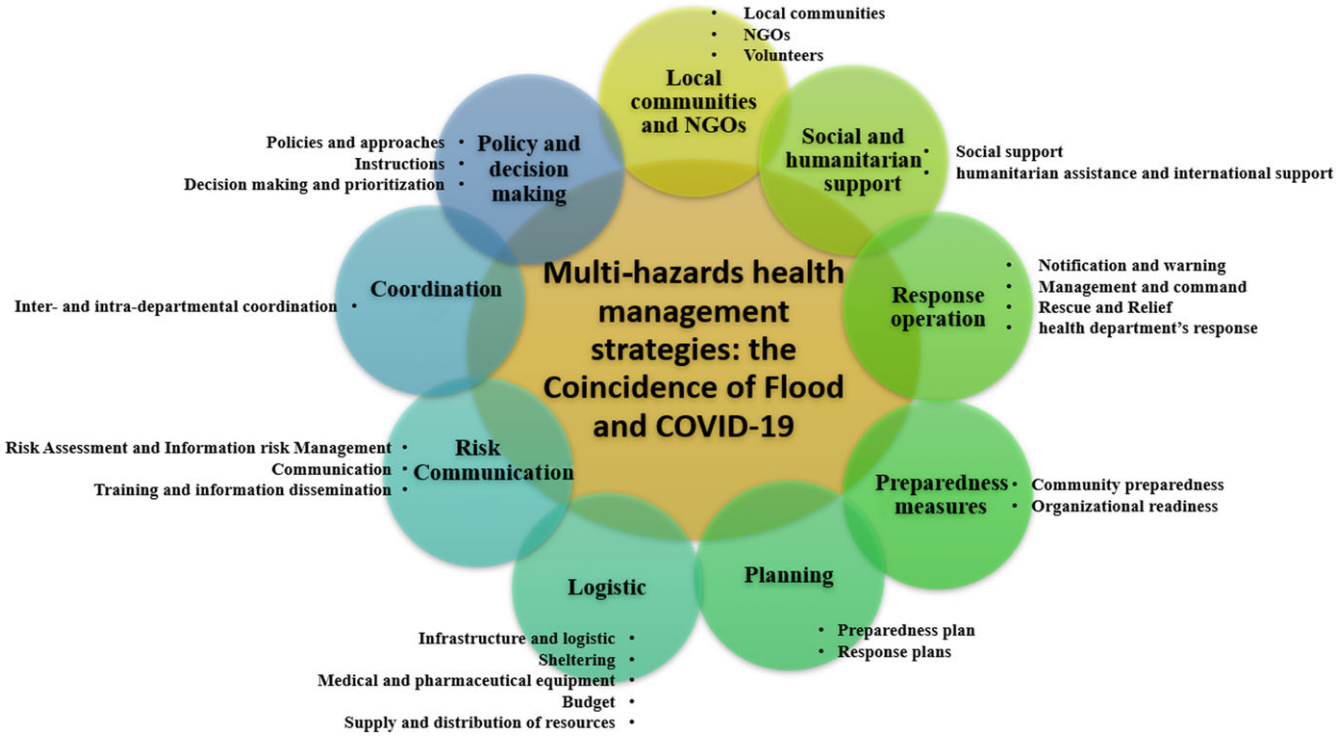

Figure 2. Multi-hazards health management conceptual framework.

reviewing studies and the experiences of countries affected by flood and COVID-19, and other emerging diseases (Figure 2). Our study findings can be beneficial in designing response protocols and managing health consequences caused by multi-hazard risks, especially for floods and emerging diseases. In addition, the classification of solutions can be very effective in policy making and decision making, coordination, risk communication, and organizing the activities of communities affected by the simultaneous flood and pandemic. Moreover, we found several categorical strategies, such as the roles of the health department, other responsible organizations and bodies, and the affected society in different phases of crisis management, including the prevention, preparation, relief, and response phases, which are also valuable. All these strategies aimed to reduce the health consequences of the co-occurring or simultaneous flood and COVID-19 with other emerging diseases.

Policy Making and Decision Making

Response and management policies for natural hazards and a pandemic are different. A pandemic requires implementing several management measures outside the routine activities of the crisis management cycle for other natural crises.[4] Flood management during a pandemic, as a multi-hazard phenomenon, requires the application of new policies and approaches,[23] including integrated policy[3] and multiple risk approach.[22] The correlation between integrated disaster management and sustainable development will lead to a new development model, reducing the consequences of disasters and strengthening resilience.[22] Moreover, maintaining human security by improving people's capabilities and participation in crisis management and involving scientists in the fields of health, water, and disaster management in policy-making and decision-making processes will be very helpful.[4] Therefore, it is recommended that approaches should be changed from reducing vulnerability to promoting resilience against disasters.[22] Increasing leaders' awareness of disaster risk reduction (DRR) measures during a pandemic,[3] using interdisciplinary knowledge and all related sciences to ensure social justice and equal access,[3] strengthening coordination mechanisms,[24] global solidarity and cooperation between countries,[3] transparent hierarchical decision making,[25] and correct prioritization[4] should be considered in policy making to respond to these crises.

Coordination

Coordination is one of the key factors in health systems' response to flood or multi-hazard.[26] Successful crisis management requires coordination among local leaders, NGOs, politicians, and all related organizations, including health, to plan and manage the coexistence of disasters with COVID-19. Local communities and stakeholders should also be well-coordinated[23] to increase access to health services to reduce the health consequences of this multi-hazard, which also requires coordination with local government and health facilities.[6] These types of coordination are effective when coordination mechanisms, networks, and operating procedures are established before the crisis,[6] services are coordinated, and people's roles are evident during the problem.[26]

Risk Communication

Disaster risk assessment is one of the foundations of development and investment in societies. Further, preparing a disaster risk map of areas at risk is one of the main components of risk assessment during a pandemic.[27] In this multi-hazard, a rapid health assessment,[28] and then establishing or activating the disease care system,[26–28] and collecting data from the care system[28] help reduce the resulting health consequences. Thus, it is essential to consider food security indicators, livelihood needs, and how COVID-19

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affects them in community assessment, in addition to health assessments.[6]

Management and response to multi-hazard floods and COVID-19 require risk communication with scientific knowledge due to the limited knowledge about pandemics in societies.[3,4] Effective and transparent information sharing can prevent rumors and the spread of wrong information.[4] Risk communication systems should have features that can save human lives, reduce consequences, and improve the level of preparedness when facing threats caused by disasters in multi-hazard situations. Providing quick and timely warnings to the whole society, using clear messages and understandable information, and conveying the message through authorized and famous institutions or media can be mentioned in this regard.[27]

In addition, preparing people for floods and promoting health awareness and prevention methods of disease transmission and pandemic growth significantly reduce the health consequences caused by the coexistence of floods and COVID-19.[4] Getting help from local leaders for training, ensuring people have timely access to information, understanding the necessary measures for prevention,[6] and making it possible for people to contact in emergencies are also recommended.[23]

Logistics

Ensuring logistics is crucial in a multiple-hazard situation, such as the supply of food and medical equipment. In some countries, a flood and COVID-19 multi-hazard led to the creation of obstacles and problems, such as reduced access and humanitarian aid due to supply chain interruption, food insecurity, lack of shelters, social distancing, and limited and unequal distribution.[25] In addition, floods and storms during the pandemic had potential effects on the aggravation of the pandemic and the increase in disease cases. During simultaneous disasters, infrastructural and logistic preparation[25] reduce health consequences caused by (1) providing equipment and technology to predict, diagnose and reduce disasters, and create the required human capacity[26]; (2) preparing quick warning and evacuation systems in the prevention phase[25,27]; (3) facilitating access to warning and messaging systems, such as using free meteorological warning applications with the ability to install on mobile phones[23]; (4) considering evacuation sites and emergency accommodation centers and camps based on risk assessment[4]; (5) applying health protocols in emergency accommodation sites[4,25]; and (6) providing medical equipment, pharmaceuticals, and sanitary items needed for the affected population.[3,24]

A pandemic like COVID-19 increases communities' needs in various aspects of health, such as medical, pharmaceutical, health equipment, livelihood, and financial markets.[29] When a pandemic coincides with a natural disaster such as a flood, the needs' intensity affects the communities' health.[4] Thus, the correct distribution of resources based on prioritization[4,26] potentially reduces the health consequences caused by a multi-generational disease. Furthermore, measures for preparing communities for natural hazards, such as flood insurance, disaster risk reduction (DRR) measures,[25] disaster financial management, and meeting the financial needs of affected communities,[3,6,25,26] can reduce the economic consequences of those impacts.

Planning

The 2030 Agenda for Sustainable Development emphasizes planning for disaster risk reduction and recommends that disaster management planning processes be integrated into development planning. Therefore, a disaster management plan should include all phases of a disaster, including pre-disaster, disaster response, and post-disaster. Integrating disaster risk management (DRM) into planning processes, such as national development plans, may pose significant challenges for governments.[30] On the other hand, COVID-19 has created new challenges because it differs from previous disasters in several ways. Global phenomena require global cooperation, and international organizations play an essential role in laying the groundwork for this cooperation.[30] Therefore, planning is one of the basic steps in flood management. Raising public awareness; establishing communication, information, and warning systems; and creating evacuation infrastructure, equipment, and rescue facilities are some actions in flood preparedness plans.[31]

In our systematic review, all measures to improve preparedness before the multi-hazard event were included in the category of preparedness programs. Developing a multi-hazard emergency management plan in the preparation phase with the following features can have a significant impact on multi-hazard management: (1) compilation of the national level plan as necessary, based on (2) the scenario of possible future events and consequences with a high probability of occurrence, with the possibility of (3) a quantitative assessment of resilience, equipped with (4) predictive scenarios for possible future consequences, and (5) ability to predict, check, and supply requirements.[22] This plan should have different features, such as the response[26] and operational strategy, especially in emergencies and the command structure,[22] roles for all departments and organizations that are clear and specific,[26] and participation and cooperation of all stakeholders.[31] Flexibility is one of the essential features of preparedness programs, given the complexity of multi-hazard situations.[22,26]

Health consequences, including deaths caused by natural disasters, are not due to the disaster's direct and immediate impact but the disaster's continuous and indirect effects, such as delays in medical care, health, and access. Moreover, the experiences of natural disasters and epidemics show the inadequate preparation and response of the health system. The frequency and severity of natural disasters are expected to increase in the coming years. Therefore, the health system should consider the response plan to strengthen preparedness and the appropriate response.[32] A comprehensive plan to respond to multi-hazard floods and pandemics should consider all aspects of multi-hazard response. A comprehensive response program to multi-hazards includes the following programs and sectors: (1) disaster response during the pandemic,[23,27] (2) epidemic evacuation program and primary health care program in flood,[26] (3) livelihood programs to integrate disaster and COVID-19 resilience,[6] (4) disaster risk assessment program,[27] and (5) operational and response protocols.[25]

The development of the multi-hazard flood and epidemic plan should also pay attention to other risk management measures, and the steps needed for additional risk management should be taken into account simultaneously. For example, there should be detailed guidelines for managing COVID-19 in the planning of disaster management like floods,[6] or a guide for the prevention, preparation, and management of emergencies, such as floods should be developed in the response plan to COVID-19.[25]

Preparedness Measures

Improving the disaster preparedness of societies is one of the practical tools to deal with the risks and consequences of

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disasters.[33] Preparedness is also essential to respond to multi-hazard floods and pandemics, and people should be ready through the development of operational plans and command structures, in addition to effective response and defense to disasters.[22] Several measures should be taken to prepare communities for the combined risks of COVID-19 and floods, such as (1) building additional evacuation centers, (2) informing communities about how to prevent the transmission of COVID-19, (3) providing essential items such as hand soap, water, and hygiene kits at evacuation sites,[6] (4) stocking essential drugs,[23] and (5) conducting evacuation and rescue drills.[3] Additionally, multi-hazard management can benefit significantly from organizational preparation in responsible and accountable organizations. Thus, a list of experienced people and organizations should be available to call them if needed.[23]

Response Operation

Most of the articles and studies were devoted to investigating response activities. Generally, the activities of the response phase can be divided into 3 stages: (1) early warning and warning, (2) response and management of disasters, and (3) rescue and relief activities.[34] Therefore, a proper warning system is necessary to respond to floods or other natural disasters during a pandemic.[27] An early warning system is effective when it can give organizations and communities enough time to prepare for a disaster.[34]

Effective management of a multi-hazard requires the timely implementation of emergency measures and several strategic interventions.[28] Implementation of preventive strategies and measures to protect areas affected by water-related disasters should prevent them from becoming new epidemic foci.[3] Outbreaks and new epidemics should be identified and controlled in a timely manner.[26] In addition, the following issues should be considered in this phase to ensure proper multi-hazard management: (1) damages caused by calamities,[26] (2) geographical location and affected area,[3] (3) deploying forces, including scientists[4] and all stakeholders,[26] (4) necessary equipment,[26] (5) evacuation centers[4] and disaster management staff,[3] (6) availability and quality of the services,[26] and (7) effectiveness of the operations.[28]

Relief and rescue operation is one of the main stages of the disaster response phase,[35] whose task is to quickly investigate and search the area affected by disasters and rescue victims.[36] To carry out rescue operations, access to areas affected by disasters is necessary.[26] In a multi-hazard context, dealing with flood-affected people with a team is also required to defend and adequately respond to floods and prevent the spread of the pandemic.[4] Thus, the following are suggested to protect human lives at this stage: protecting evacuees or people housed in evacuation centers against the threat of COVID-19,[3] saving patients with COVID-19 against the threat of flood,[4] preserving rescue workers during defense against flooding principles, and observing the principles of protection against the pandemic and COVID-19 restrictions, such as social distance.[4,23]

The health department's response is also critical in the case of multiple hazards. Timely health measures, compliance with the correct health protocols,[25] and raising health awareness in the affected area[4] can prevent the spread of the pandemic in the flood-affected areas and reduce multi-hazard health consequences. Some of these measures that health teams should take are: activating community health brigades,[25] monitoring the health of the community[3] when declaring an emergency, providing health and wellness services, especially in rural areas,[26] increasing flood disaster management measures in health care facilities where people are sick or infected with COVID-19,[4] using properly designed toilets to prevent contamination of underground water sources, controlling critical points for managing waste infected with the COVID-19 virus in medical centers or field hospitals, early diagnosing COVID-19 patients in the displaced population, isolating sick people by establishing a care system in emergency camps and temporary accommodations,[24] providing clean water[3] and sanitary items,[25] individual health and social health sustainably during and after the flood disaster,[3] preparing health system service providers such as nurses and knowledgeable doctors,[25] and providing counseling and psychological support to flood victims, especially families who have lost members to COVID-19.[24]

Additionally, the flood victims should cooperate with the health management teams to prevent the spread of pandemics and reduce the health consequences of the flood[23] and maintain the following activities: maintaining social distance[23] during the process of evacuation from areas at risk and in temporary residences,[25] avoiding crowding in evacuation centers and staying at home, if possible,[4] wearing a mask,[3,24] especially during evacuation or in evacuation centers,[23] cleaning and implementing disinfection protocols,[3,23] decontaminating surfaces with water and detergents,[24] and not using the food contaminated with floods, even canned food.[23]

Social and Humanitarian Support

Despite travel and movement restrictions during the pandemic, multi-hazard management requires humanitarian assistance and international support even in the worst-case scenario.[4] Therefore, restrictions on shipments of international aid should be minimized. In addition, to prevent the spread of the COVID-19 pandemic, the disinfection of shipments should be considered.[23] Moreover, vulnerable groups, that is, older adults and informal immigrants with limited access to health services and WASH facilities, including waste management, should be given special attention[4] by providing them with food and monetary support,[6] arranging special places for the older adults and those with a disability, and protecting human rights.[23]

Local Communities and NGOs

Since, during the COVID-19 pandemic, floods occurred in many countries, timely foreign support cannot be expected as it was in the pre-COVID-19 period. Therefore, local organizations' and communities' capacity and participation should be increased to manage multi-hazard situations.[4] The roles of volunteers in helping COVID-19 patients,[27] supplying clean water, and rebuilding houses affected by floods[4,23] can be very effective in multi-hazard management. Financial and personnel support of local communities and union disaster management committees (UDMCs) is necessary to strengthen and increase the capacity of local communities.[6]

Conclusion

This systematic study examined strategies for managing the health consequences of co-occurring flood and COVID-19, as well as other emerging diseases. Managing a multi-hazard and reducing the health consequences require a wide range of actions, including policy and decision making, coordination, risk communication, logistics, planning, preparedness, response, and social and

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humanitarian support. Activities should not aggravate the consequences of health and life caused by COVID-19 and should prevent the further spread of COVID-19 in flooded areas while managing the flood disaster and protecting the affected people's health and livelihoods.

Based on the findings of this study, no study has examined the views and attitudes of the health system people involved in managing and responding to this multi-hazard. In addition, no protocol or program has been designed for this purpose. Therefore, fundamental studies are needed to evaluate the viewpoint of officials and experts in health systems, designing protocols, and methods of responding to multi-hazards. In addition, attention should be paid to the health recovery of communities affected by floods during the COVID-19 pandemic.

Supplementary material. To view supplementary material for this article, please visit https://doi.org/10.1017/dmp.2024.46

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