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The consequences of floods as an extreme weather event for public health: risks and prevention strategies

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ABSTRACT

Introduction and Goals. Global warming has intensified floods and extreme weather events in the Mediterranean basin, causing a severe impact on public health and infrastructure. This study aims to review the available evidence (2014-2025), characterise risk groups and propose recommendations to reinforce health resilience. Material and Methods: A scoping review was conducted in accordance with PRISMA-ScR from January to April 2025, searching PubMed, Scopus and WoS for studies related to disease, flooding and mud. 29 papers were selected after screening and evaluation with JBI.

Material and Method. Drawing up the system involved several different phases: conceptual design, analysis of paper systems, review of variables and data, design of the electronic register, prototyping, evaluation of connections and interoperability, validation of the prototype and implementation.

Results. Infectious diseases (gastroenteritis, dengue, legionellosis), non-communicable diseases (stroke, cardiovascular) and mental disorders (depression, PTSD) were identified, with greater presence in older adults, children, women and rural areas; the acute burden of diarrhoea arises between 4 and 12 days after the event, while arbovirosis and chronic complications increase thereafter; health care is hampered by power cuts and road damage.

Conclusions. Floods, such as the Valencia DANA (cold drop), cause acute health burden and prolonged sequelae, especially in vulnerable populations, requiring real-time epidemiological vigilance, ongoing care, psychosocial support and infrastructure improvements based on climate scenarios. Artificial intelligence and specialised personnel are key to anticipating risks and meeting the SDG 3 targets and the Sendai Framework.

INTRODUCTION

The 2021 report of the Intergovernmental Panel on Climate Change (IPCC) notes that climate change involves not only a gradual increase in temperatures but also an intensification of climate variability including extreme events. There is a high degree of scientific confidence that human activities (especially the burning of fossil fuels) are responsible for increasing energy in the climate system, resulting in more intense and prolonged heat waves, torrential rain, devastating hurricanes and severe droughts (1).

The warning from the Spanish State Meteorological Agency (AEMET in Spanish) in its 2020 report (2) shows that global warming is causing changes in marine features near Spain, with significant consequences for marine life and coastal populations. According to Olcina's research (3), there is now a solid scientific basis detailing how climate warming impacts on rainfall and temperature in the Spanish Mediterranean. Furthermore, the Mediterranean is considered a natural laboratory for studying the effects of climate change. Research in this region can help predict potential risks and responses that could be applicable to other parts of the world. Regarding the climate trend in Spain, an increase in the frequency and intensity of extreme events, such as heat waves and torrential rains caused by cold drop (DANA[1] in Spanish), can be observed (4).

THEORETICAL MODEL

Olcina (3) coined the term 'Mediterraneanisation' to refer to a process whereby other regions of the planet are beginning to experience climatic, social and territorial dynamics similar to those of the Mediterranean area, characterised by

- Increased frequency and intensity of extreme phenomena (heat waves, droughts, DANA, fires).
- Increased social and territorial vulnerability.
- Pressure on water resources.
- Difficulties in urban and health adaptation

According to the World Health Organisation (WHO) (5) the social determinants of health are "the circumstances in which people are born, grow, live, work and age, including the health system". The social determinants of the health model proposed by Dahlgren and Whitehead (6) and endorsed by the WHO (7) is one of the most widely used conceptual frameworks for understanding how social, economic and environmental factors influence people's health (6, 7).

Figure 1: The social determinants of health identified by Whitehead & Dahlgren (6)

[1] *The Spanish initials stand for Depresión Aislada en Niveles Altos, i.e. Isolated Depression at High Levels. It is a low pressure system that forms high in the atmosphere and is isolated from the general air circulation.*

The framework of factors that influence public health provides a comprehensive and systemic perspective on the various elements that impact human well-being. This approach encompasses both individual and collective aspects related not only to the health domain itself but also to the social and economic context in which people live. Source: Whitehead & Dahlgren (6).

The IPCC (8) points out that the threat related to climate change is not limited exclusively to extreme weather or extreme events. It stresses that climate risk is not simply a purely natural phenomenon. Instead, it is a result of several different interrelated factors that can be managed or modified by means of the appropriate policies.

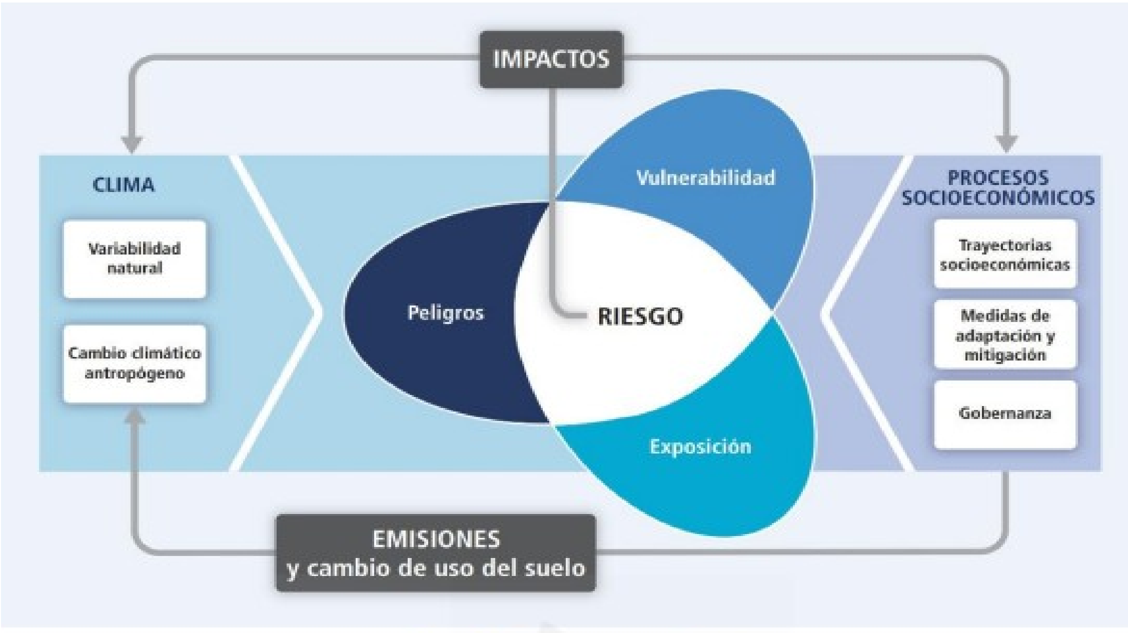

Figure 2: Components of climate risk

The IPCC conceives risk as the product of the interaction of climate-related hazards with the vulnerability and exposure of human and natural systems. Source: IPCC (8).

Furthermore, the Sendai Framework for Disaster Risk Reduction 2015-2030 is a key instrument that was adopted by UN Member States in March 2015, during the 3rd United Nations World Conference on Disaster Risk Reduction (UNDRR) (9) in Sendai, Japan. This framework succeeds the Hyogo Strategy (2005-2015) and constitutes a global commitment to reducing disaster risks and increasing resilience to natural and anthropogenic hazards. It sets out four priorities for action:

- Understanding disaster risk.
- Reinforcing disaster risk governance to better manage disaster risk.
- Investing in risk reduction for greater resilience.
- Improving preparedness for response and 'build back better' during recovery, rehabilitation and reconstruction.

It also defines seven global goals, such as reducing mortality, minimising economic losses and increasing international cooperation, among others (9).

The model for analysing social vulnerability to flood disasters proposed by Ortiz et al. (10) is a useful tool for diagnosing social impact and capacities, both in the pre-disaster preparedness phase and in the response and intervention during the post-disaster period. In the context of the devastating effects caused by the DANA that occurred in Valencia in October 2024, the model provides a sociological perspective that makes it possible to identify key elements for strengthening the resilience of social and governance systems in the face of the effects of climate change.

Figure 3: Model for integrating the different levels of the generative process of social vulnerability to flood risk

It distinguishes three main levels or stages of social vulnerability to flood risk, referring to the three main lines of research described above, namely: the generative level, the adaptive level and the experiential level, which thus covers the whole cycle of the flood, from its deepest origin (pre-event), via the activation of capacities and the response to the hazard (event), to the ultimate experience of the impact and its transformation into new vulnerabilities (post-event). The model thus incorporates both the structural vulnerability inherent to the social system exposed to flood risk and the vulnerability acquired from the experience of impact and the creation of a new post-disaster social scenario. Source: Ortiz et al. (10).

From this perspective, the study investigates how climate shocks aggravated by global change affect public health, considering physical, mental and social aspects, with an emphasis on vulnerability, resilience and equality. The general objective is to analyse the peer-reviewed literature on the impact of extreme weather events such as floods and storms on people exposed to mud after such emergencies, while the specific goals seek to identify relevant studies, assess the repercussions on vulnerable groups, analyse adaptation measures and synthesise recommendations for future research and action in the face of climate change.

METHODOLOGY

The review was conducted in accordance with the PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines for systematic reviews and meta-analyses (PRISMA-ScR) (11), which guarantees transparency, completeness and reproducibility.

Table 1: Search strategy: Condition, Context, Population model (CoCoPop)

Element	Key words
Condition	Development of diseases
Context	After flooding
Population	People exposed to mud
Research question	What diseases can people who are continuously exposed to mud after flooding suffer from?

The search strategy was designed according to the CoCoPop model proposed by Munn et al. [2] Prepared by the author.

The searches were carried out from January to April 2025, using the following databases: PubMed, Scopus and Web of Science. Key terms were combined using Boolean operators and limited by publication date (01-01-2014 to 01-03-2025). Only articles in English or Spanish, with the full text available, were included.

The following criteria were used to select articles:

a) Inclusion criteria:

- Empirical studies analysing the impact of floods on health.
- Quantitative and qualitative designs (cross-sectional, cohort, case-control, RCTs).
- Peer-reviewed articles, published in English or Spanish, with access to the full text.
- Access to the full text to be able to access all the information in the study.
- Published from 01-01-2014 to 01-03-2025.

b) Exclusion criteria:

- Technical reports and systematic reviews.
- Studies not focused on health after floods.
- Articles without full access or with low methodological quality.

The initial search strategies identified 111 references, which were further screened according to the topic of this review.

[2] *Munn Z, Moola S, Lisy K, Riitano D, Tufanaru C. Methodological guidance for systematic reviews of observational epidemiological studies reporting prevalence and incidence data. Int J Evid Based Healthcare. [Internet] 2015; 13 (3):147–153. [Consulted on 28 March 2025] doi:10.1097/XEB.0000000000000054.*

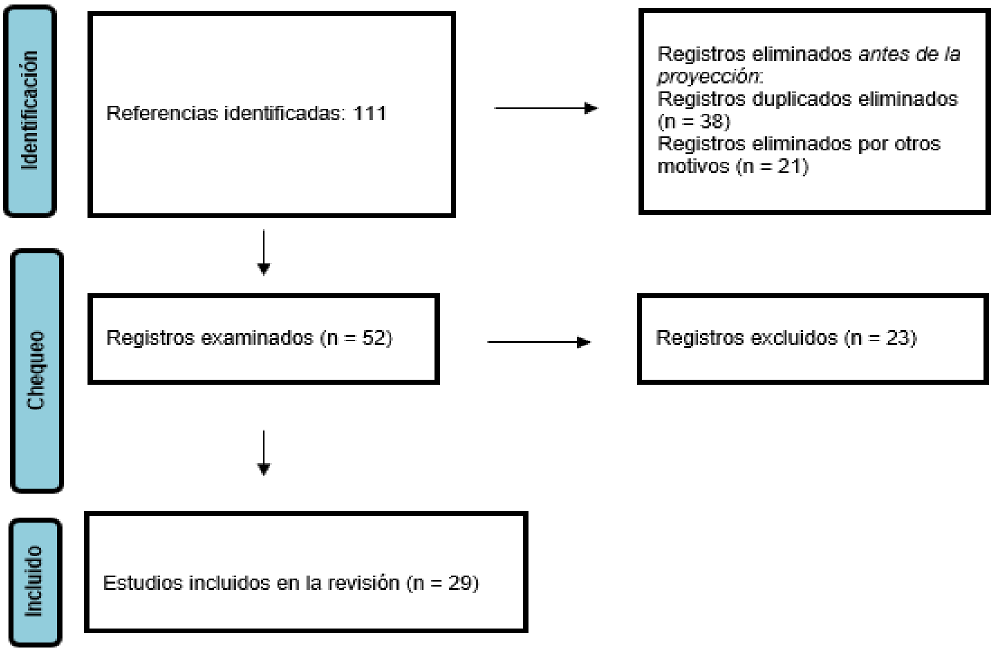

Figure 4: Search results – Flow chart – PRISMA

The initial search strategies identified 111 references, which were further screened according to the topic of this review. Source: Page et al. (11)

Study selection was conducted in two phases: title/abstract review and full-text assessment. The studies included were assessed with the critical appraisal tool of the Joanna Briggs Institute (JBI) at the University of Adelaide, where they scored medium-high for both cross-sectional observational studies and qualitative studies. Finally, 29 studies were included: 27 quantitative and 2 qualitative. Synthesis was carried out by narrative analysis, with representation in tables, graphs and explanatory text.

RESULTS

29 articles were identified:

- Eight were written in the USA (12 - 19), six in China (20 - 25), two each in Pakistan (26, 27), Australia (28, 29) and Ethiopia (30, 31), and one each in Japan (32), the Himalayan region (33), Turkey (34), Ecuador (35), Paraguay (36), Peru (37), Ireland (38) and Greece (39). In addition, Liu et al. (40) analysed aggregate data from 168 countries.
- Eight papers focused on populations affected by extreme weather events (floods, hurricanes, typhoons). Three assessed the impact on children (30, 33, 36) and two on older adults (13, 16). Seven addressed psychosocial or socio-economic factors linked to vulnerability (17, 19, 24, 27, 31, 34, 35).

As far as morbidity related to flooding is concerned, the following articles were found:

- 12 articles on general infectious diseases, 3 general (20, 39, 40), 5 enteric (21, 22, 23, 30, 37), 1 mosquito-borne (28), 1 dengue-specific (26), 1 legionella (12), and 1 dermatological (36).
- 5 on non-communicable diseases (13, 14, 15, 17, 32).
- 2 on mental health (14, 25)

Table 2: Comprehensive synthesis of the findings in the 29 studies. The synthesis was put together by means of narrative analysis, showing a representation in a summary table and an explanatory text. Prepared by the author.

Topic	Main quantitative / qualitative results	Populations / Context highlighted	Ref.
Overall magnitude 1990-2019	47,368 days with floods in 168 different countries 242,516 deaths - 3.55×10^9 people affected Average flood duration ↑ 5.1% (95% CI 3.6-7.2); mortality rate ↓ 0.8%; people affected ↓ 3.1%	The whole planet (aggregate data)	40
General health risk patterns	Pre-event 'fragility', impact factors and post-event factors determine disease burden Mismanagement can release hazardous substances • Direct damage (drowning, trauma), indirect damage (infectious diseases, environmental pollution)	All the regions studied	24, 36, 37, 39, 40
Temporal distribution of pathologies	<u>Short term</u>: gastroenteritis, ARI, trauma <u>Medium term</u>: leptospirosis, dengue, exacerbation of chronic conditions <u>Long term</u>: hepatitis, malaria, mental health disorders	Flooded communities (Asia, America, Oceania)	36
Dominant infectious diseases	<u>Arbovirosis</u>: dengue, West Nile V., malaria <u>Respiratory</u>: legionellosis +32 % with extreme rainfall <u>Enteric</u>: dysentery and infant diarrhoea ↑ 4-12 d post-event <u>Cutaneous</u>: pediculosis, scabies, impetigo in shelters	Tropical and subtropical zones; temporary shelters	12, 22, 23, 26, 27, 28, 30, 36
Non-communicable diseases (NCDs)	Stroke ↑ after typhoon (Japan) Cardiovascular hospitalisations ↑ after Katrina (USA) Respiratory disorders and injuries ↑ in week 3 post-hurricane (USA)	Japan, USA.	13, 18, 32
Mental health	Ongoing prevalence of depression, anxiety and PTSD up to 20 years later (China) Prolonged post-Harvey stress; socio-economic differences in resilience Severe psychosocial impact on children and adolescents (India)	Adult survivors; children / adolescents	14, 25, 33
Vulnerable groups	Adults ≥60: 9,039 deaths (1999-2017); men and ethnic minorities with higher rates Mortality +20.6% in nursing homes (Harvey) Greater sensitivity: children, women, rural/poor households, recent migrants	USA, Pakistan, India, China	16, 17, 19, 24, 31, 35
Socio-economic impact	"Very low" incomes ↑ from 3.6 % to 30 % after floods (Pakistan) Willingness to relocate greater in the face of landslides than floods; influenced by fear, social support and chronic disease	Pakistan, Turkey	27, 34
Health services and logistics	Damage to roads, power grid and health facilities all limit care Power outages compromise water and hospitals Overall ED visits stable; ↑ 9-11 % in remote counties week 3 post-hurricane; dose-response distance effect	USA, numerous other countries	15, 17, 21
Health risk factors by stage	<u>Pre-event / event</u>: vulnerable infrastructure <u>Event / post-event</u>: contaminated water, proliferation of rodents and mosquitoes, injuries from debris <u>Post-event</u>: waste, mould and crowding	Table drawn up from 16 studies	12, 14, 15, 20-23, 26-30, 35-40

Following the analysis of the 29 articles selected for this scoping review, it was possible to identify global epidemiological trends, specific patterns of communicable and non-communicable diseases associated with floods, impacts on mental health, particularly vulnerable population groups, as well as key factors related to adaptive capacity and health response to these extreme events.

DISCUSSION

Among the main lessons learned from the Valencia DANA or cold drop (29 October 2024) are serious deficiencies in urban planning, a lack of technical preparedness and insufficient pre-event infrastructure, a slow and uncoordinated institutional response during the event, and logistical, informational and technological problems after the disaster (41).

The results of this review confirm that floods, intensified by anthropogenic climate change (1), are a growing threat to public health globally and locally. This phenomenon generates complex health impacts, especially in Mediterranean regions, considered a ‘natural laboratory’ for studying these effects (3). In Spain and the Mediterranean area, an increase in the frequency and intensity of extreme events such as DANAs and flash floods has been documented (3, 4). The AEMET warns that these changes affect both infrastructure and the physical and mental health of coastal populations (4). Furthermore, studies such as Olcina’s (3) show a direct relationship between the increase in average temperatures and the probability of extreme events with health consequences. However, local studies such as that of Sánchez-Almodóvar et al. (42) on extreme precipitation in Alicante do not show a significant increase in frequency or intensity over recent decades, suggesting that it is not always possible to directly link these events to global warming on a local scale, in contrast to what has been proposed for the Mediterranean as a whole.

DIRECT AND INDIRECT HEALTH IMPACTS

The research findings are consistent with previous evidence synthesised by Alderman et al (43) and also reflect the temporal evolution of disease as described by Liu et al (40).

Enteric and waterborne infections remain one of the most frequent acute outcomes following floods, with notable peaks in childhood diarrhoea 4-12 days after the event. This is consistent with international reviews linking extreme rainfall and drinking water treatment failures to outbreaks (41, 44, 45). Furthermore, an increase in arboviruses such as dengue and West Nile virus, a phenomenon already anticipated by Githeko et al. (46) more than two decades ago, has been observed, as well as malaria in areas where it was not previously endemic.

Five articles documented an excess of hospitalisations for stroke and cardiovascular events – up to 16% in the week following the typhoon in Japan – as well as an increase in traumatic injuries following hurricanes. In addition, significant health risks were identified due to contamination by infectious agents carried by mud and water, requiring early and prolonged environmental sampling campaigns (41). These results highlight the urgent need for strategies to ensure ongoing care for chronic patients during disasters.

Two longitudinal studies included showed persistent prevalences of depression, anxiety and PTSD up to 20 years after exposure (14, 25), a finding consistent with the long-term burden described after Katrina and other disasters (47). The most commonly cited protective factors were social support and socioeconomic status; however, few studies evaluated formal psychosocial interventions, a gap already noted by Goldmann and Galea (48).

VULNERABLE GROUPS AND INEQUALITY

Among the main problems identified in the aftermath of the Valencia disaster were the physical and mental vulnerability of older people, which underlines the importance of prioritising this group in future interventions (41). The integrated analysis proposed by Ortiz et al. (10) is particularly useful for identifying critical factors before/during/after the disaster and implementing equitable interventions aimed at reinforcing community resilience. In addition, rural households, women and recent migrants showed a higher risk of illness and post-event impoverishment, a reminder that vulnerability is socially determined (49). These findings support the Sendai Strategy's recommendation to integrate equity and life-cycle approaches into risk reduction plans (9).

HEALTH RESILIENCE: CHALLENGES AND OPPORTUNITIES

The multidisciplinary analysis presented of the Valencia event by Mas-Coma et al. (41) reveals the enormous complexity of these events and the need for comprehensive assessments before, during and after the disaster to fully understand its evolution and consequences. The application of the One Health approach is essential as it allows for addressing the interactions between human, animal, plant and environmental factors in rural, urban and natural contexts, integrating socio-political, ethical and legal dimensions. This framework facilitates the identification of individual infectious risks and potential outbreaks arising from the spread of pathogens through contaminated water.

Damaged roads, power outages and flooded hospitals cause multiple challenges to the health system: reduced supply and increased demand. The WHO Operational Framework for Climate Resilient Health Systems emphasises a preventive-adaptive approach (50). As recommended by the Sendai Framework for Disaster Risk Reduction 2015-2030 (9), it is essential to invest in prevention, improve risk governance and integrate multi-sectoral strategies including enhanced epidemiological vigilance after floods. Specific and Artificial Intelligence (AI)-supported opportunities are identified to move towards more resilient health systems:

- Early implementation of epidemiological alerts;
- Specific protocols for continuity of care for chronic patients;
- Sustained psychosocial support for affected population;
- Adaptation of infrastructure based on future climate scenarios

LIMITATIONS AND FUTURE LINES OF RESEARCH

This review has several limitations. Firstly, most of the studies reviewed focus on specific regions, making it difficult to generalise the results to other contexts. In addition, there is a potential bias in disease reporting due to the limited capacity of health systems to register cases, especially in resource-poor countries. Methodological heterogeneity among studies complicates direct comparison of results, and in general, short-term analyses predominate without accurately assessing long-term effects, especially in mental health. Finally, as a scoping review, the paper prioritises general mapping over exhaustive synthesis.

Despite these limitations, the study provides a useful basis for future research and highlights the need to broaden the analysis of post-flood emotional well-being and associated social inequalities. Further research on cost-effective interventions to reduce post-disaster inequalities and incorporate participatory methodologies that give voice to vulnerable communities is recommended.

CONCLUSIONS

This research shows that climate change is increasing the frequency and severity of floods and other extreme events in the Mediterranean, negatively impacting both infrastructure and the physical and mental health of the population, especially among the most vulnerable. The study supports Sustainable Development Goal 3 (SDG 3: Health and well-being), among others, by providing resources and strategies to prevent diseases, reinforce mental health and improve risk management in the face of natural disasters. It also highlights the need for access to up-to-date information on epidemiological vigilance, community resilience and early warning systems, as well as the key role of digital technologies and AI in optimising health response. Finally, it concludes that addressing these challenges requires skilled personnel and comprehensive planning based on science, technology and social inclusion to reduce the impact of climate change on public health.

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ANNEXES

ANNEX 1
PRISMA-SCR CHECKLIST. ITEMS FOR SYSTEMATIC REVIEWS AND META-ANALYSES - EXTENSION FOR SCOPING REVIEWS

SECTION	ITEM	PRISMA-ScR ITEM CHECKLIST	
TITLE			
Title	1	Identify the report as a scoping review.	✔
ABSTRACT			
Structured summary	2	Provide a structured summary including (as appropriate): background, goals, eligibility criteria, sources of evidence, data extraction methods, results and conclusions related to the review questions and goals.	✔
INTRODUCTION			
Rationale	3	Describe the rationale for the review in the context of what is already known. Explain why the questions or goals lend themselves to a scoping approach.	✔
Goals	4	Provide an explicit statement of the questions and goals being addressed with reference to their key elements (e.g. population or participants, concepts and context) or other relevant elements used to conceptualise the review questions and/or goals.	✔
METHODOLOGY			
Protocol and register	5	State whether there is a review protocol, specify whether it is accessible (e.g. web address), and if available, provide registration information, including registration number.	✖
Eligibility criteria	6	Specify the characteristics of the evidence sources used as eligibility criteria (e.g. years considered, language and publication status) and provide a, explanation.	✔
Sources of information*	7	Describe all sources of information used in the search (e.g. databases with dates of coverage and contact with authors to identify additional sources), as well as the date of the most recent search.	✔

SECTION	ITEM	PRISMA-ScR ITEM CHECKLIST	
Search strategy	8	Present the complete electronic search strategy for at least one database, including the limits used, in a reproducible form.	✔
Selection of sources of evidence†	9	Describe the process for selecting the sources of evidence (i.e. screening and eligibility) included in the scoping review.	✔
Charting process ‡	10	Describe the methods of data extraction from the evidence sources included (e.g. forms calibrated or pre-tested by the team, and whether the extraction was done independently or in duplicate), and any process for obtaining and confirming data with researchers.	✔
Data elements	11	List and define all variables for which data were sought, as well as any assumptions and simplifications made.	✔
Critical evaluation of individual sources §	12	If done, provide a rationale for a critical appraisal of the sources of evidence included, and describe the methods used and how this information was used in any data synthesis (if applicable).	✔
Synthesis of results	13	Describe the methods of handling and summarising the data extracted.	✔
RESULTS			
Selection of sources of evidence	14	State the number of sources of evidence examined, assessed for eligibility and included in the review, with reasons for exclusion at each stage, ideally using a flow chart.	✔
Characteristics of sources of evidence	15	For each source of evidence, describe the characteristics by which the data was extracted and provide citations.	✔
Critical evaluation within sources of evidence	16	If conducted, present the critical appraisal data for the sources of evidence included (see item 12).	✔
Results from individual sources	17	For each source of evidence included, present the relevant data extracted that relates to the review questions and goals.	✔
Synthesis of results	18	Summarise and/or present the results of the data extracted in relation to the review questions and goals.	✔
CONCLUSIONS			

SECTION	ITEM	PRISMA-ScR ITEM CHECKLIST	
Summary of the evidence	19	Summarise the main findings (including an overview of concepts, issues and types of evidence available), relate them to the review questions and goals, and consider their relevance to key groups	✔
Limitations	20	Discuss the limitations of the scoping review process.	✔
Conclusions	21	Provide an overall interpretation of the results with regard to the review questions and goals, as well as potential implications and/or next steps.	✔
FINANCING			
Financing	22	Describe the sources of funding for the sources of evidence included, as well as the sources of funding for the scoping review. Describe the role of the funders of the review.	✖

JBI = Joanna Briggs Institute; PRISMA-ScR = Preferred Reporting Items for Systematic reviews and Meta-Analyses – Extension for Scoping Reviews.

Places from which sources of evidence are collected (see second footnote), such as bibliographic databases, social media platforms and websites.

† A more inclusive/heterogeneous term used to encompass the different types of evidence or data sources (e.g. quantitative and/or qualitative research, expert opinion and policy documents) that may be eligible in a scoping review, as opposed to mere studies. Not to be confused with information sources (see first footnote).

‡ The frameworks of Arksey and O'Malley (6), Levac et al. (7), together with the JBI guidance (4, 5), refer to the process of data extraction in a scoping review as 'data mining' or 'charting'.

§ The process of systematically examining research evidence to assess its validity, findings and relevance before using it to inform a decision. This term is used in items 12 and 19 instead of 'risk of bias' (more applicable to systematic reviews of interventions), in order to include and acknowledge the various sources of evidence that may be used in a scoping review (e.g. quantitative and/or qualitative research, expert opinion and policy documents).

Source: Tricco AC, Lillie E, Zarin W, O'Brien KK, Colquhoun H, Levac D, et al. PRISMA Extension for Scoping Reviews (PRISMA-ScR): Checklist and Explanation. Ann Intern Med. [Internet] 2018;169(7):467–473. [Consulted 28 March 2025] Available at: doi: 10.7326/M18-0850.

ANNEX 2
COMPLETE LIST OF STUDIES INCLUDED IN THE SCOPING REVIEW

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Liu et al. (40)	168 countries and territories from 1990 to 2019	To determine whether there is a statistically significant relationship between natural floods and increased frequency of infectious diseases in different countries and territories worldwide.	Observational study	Covers all countries and territories with reported flood disasters.	Generalised linear quasi-Poisson models were used to analyse the relationship between flood disasters and infectious diseases.	There is a significant positive correlation between floods and an increase in cases of infectious diseases, especially diarrhoea, cholera and malaria. The relationship is strongest in low-income countries. After a flood, an increase in the frequency of these diseases is observed for a certain period of time.	6.5/8
Colston et al. (37)	Loreto (Peru)	To understand the impact of enteric infections in a cohort of children in Peru (part of the MAL-ED project).	Multicentre study	Data was collected from birth cohorts recruited from eight different communities, each in a different low- or middle-income country. Subjects were enrolled and monitored continuously over their first 2 years of life, from November 2009 to March 2014.	An interrupted time series analysis was used to identify specific changes in the prevalence of different pathogens during and after the flood.	Flooding significantly increased the impact of infections caused by certain enteric pathogens. Changes in the distribution of pathogens were observed before and after the climate event. The analysis helped understand how extreme weather events can influence the burden of infectious diseases in vulnerable communities.	7/8
Ding et al. (20)	Guangxi (China)	To quantitatively identify sensitive infectious diseases associated with floods in Guangxi, China.	Ecological study	The population under study.	A time-trend ecological study was conducted to identify flood-sensitive diseases. Exposure periods (with flooding) were compared to control periods (no flooding) using a time-stratified design.	The results show that floods can significantly increase the concentration of certain pollutants in drinking and surface water.	6.5/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Luo et al. (21)	Changsha (China)	To research how different levels of storm flooding affected the impact of enteric infectious diseases in Changsha in the period 2016-2020.	Ecological time-series study	Eleven floods were recorded in the period, concentrated in the months of June and July.	Data collected on enteric infectious diseases, floods and weather conditions in Changsha (2016-2020). Use of Wilcoxon rank sum test to identify associations. Analysis using a non-linear distributed lag model to assess specific lagged effects by flood level.	Typhoid/Paratyphoid Fever: showed a significant increase in risk on days 1 and 2 after a flood, with the highest cumulative risk on day 4. Bacillary Dysentery: Risk was highest from days 1 to 5 after a flood, peaking on day 3; effects lasted up to one month. Frequency rates were significantly higher on days with flooding compared to days with no flooding.	7/8
Mavroulis et al. (39)	Thessaly (Greece)	To assess the impact of Storm Daniel in September 2023 and subsequent flooding on the natural and built-up environment, as well as on the occurrence and distribution of infectious diseases in the region of Thessaly, Greece.	Observational study	The zones and populations affected.	Field surveys were conducted to collect information on the impact of flooding on water bodies, agricultural land, critical infrastructure and more. The data was evaluated to identify factors that could favour the emergence of infectious diseases. Measures taken by the Greek authorities were reviewed based on previous experiences worldwide.	The results showed that the floods caused by Storm Daniel caused significant damage to the natural and built-up environment in Thessaly. In addition, a marked increase in certain infectious diseases was observed after the event, suggesting a direct link between the floods and the occurrence or increase of these pathologies.	7/8
Saeed et al. (26)	Nowshera (Pakistan)	To assess an outbreak of dengue disease during the floods among patients who went to a tertiary level hospital.	Cross-sectional study	925 dengue patients: 583 (63%) men, 245 (26.4%) women, 97 (10.6%) children.	A sample size of 385 was calculated using the WHO sample size calculator (95% CI). Consecutive universal sampling was used to collect data from patients with confirmed dengue. Inclusion criteria covered individuals of all ages and genders with confirmed dengue. Patients testing negative for dengue, malaria, typhoid fever or immune thrombocytopenic purpura were excluded. Data on monthly dengue cases, comorbidities, recovery and mortality were analysed using descriptive statistics.	Dengue occurred most frequently in the 20-35 age group (38.1%). The outbreak started with only 6 cases reported in July 2022 after the first case on 25 July. The number of positive cases increased in the following months: August: 223 cases, September: 425 cases, October: 210 cases, November: 61 cases. This represents a dramatic increase compared to the same period in the previous year.	6.5/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Adekunle et al. (28)	Townsville, North Queensland (Australia)	To assess the impact of flooding on mosquito-borne disease (MSD) in Townsville in 2019.	Observational study.	Epidemiological, environmental and entomological data related to the affected area. According to the 2016 census, Townsville had a population of approximately 226,031 people. In 2018, 310 cases of mosquito-borne diseases were reported.	A mathematical model taking into account factors such as the abundance, survival and population size of mosquitoes, as well as their current level of infectivity, to predict how flooding could affect MSD in the region.	The model predicts a temporary increase in cases after flooding, peaking before decreasing again if (R_0) remains below one. However, if (R_0) exceeds one due to changes in bite rate or carrying capacity, MBD could become endemic.	6.5/8
Lynch and Chaman, (12)	USA	To determine the association between extreme and seasonal flooding and Legionnaires' disease hospitalisations in 25 different US states.	Ecological time-series study.	Aggregate inpatient data and epidemiological records to analyse the association between flooding and cases of legionellosis.	Temporal analysis to identify peaks in hospitalisations related to periods of flooding. Multivariate statistical models (e.g. regressions) to adjust for potential confounders such as seasonality, climate variables and demographic characteristics. The association between the occurrence of flooding (seasonal and extreme) and the relative risk or rate of hospitalisation for legionellosis was assessed.	Evidence was found that both extreme and seasonal flooding are associated with an increase in hospitalisation rates.	6.5/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Zhang et al. (22)	Qingdao (China)	To assess the short-term impact of flooding on enteric infectious diseases in Qingdao from 2005 to 2011.	Ecological time-series study.	Reported cases of enteric infectious diseases in Qingdao in the period, with clear criteria for inclusion.	A time-series epidemiological analysis to assess the short-term impact of floods on enteric infectious diseases in Qingdao, China, in the period 2005-2011. The study focused on analysing the relationship between floods and three enteric infectious diseases: bacillary dysentery (BD), hand-foot-mouth disease (HFMD) and other infectious diarrhoea (OID).	Using a generalised linear quasi-Poisson model, relative risks (RR) and 95% CIs were calculated to assess the impact of flooding on these diseases, adjusting for factors such as mean daily temperature, mean daily relative humidity and seasonal trends. Two models were designed for different periods: Model 1 (Summer Period): Flooding showed a positive association with bacillary dysentery (BD) for lags of 4-12 days, most pronounced at 7 days (RR 1.41, 95% CI 1.22-1.62) and 11 days (RR 1.42, 95% CI 1.22-1.64). Model 2 (All Study Period): Similar results were observed for BD with lags of 5-12 days.	6.5/8
Liao et al. (23)	Anhui province, (China)	To determine whether flooding has a direct and measurable impact on the increase in cases of infectious diarrhoea, checking for other factors that may influence outcomes.	Quasi-experimental study.	Residents of Anhui Province, China, in the period when data on flooding and cases of infectious diarrhoea was collected.	The study divided the period into three different phases: before the flood (18 June 2013 - 17 June 2016), during the flood (18 June - 31 August 2016) and after the flood (1 September 2016 - 31 August 2017). Statistical analyses: Propensity Score Matching (PSM), DID Analysis and DDD Analysis.	Analysing 359,580 cases of diarrhoea before, during and after the event, it was found that flooding significantly increased the risk of dysentery (RR: 1.29) during the flood and the overall risk of all-cause diarrhoea (RR: 1.21) in the aftermath. Children, men and non-farmers were particularly vulnerable, while a higher density of health workers provided protection against the risk of diarrhoea both during (RR: 0.81) and after (RR: 0.83) the event.	6.5/8
Birhan et al. (30).	Gondar (Ethiopia)	To assess the prevalence of diarrhoea and predictors in children under five years of age in flood-vulnerable communities in South Gondar, Ethiopia.	Cross-sectional study	Children under five in flood-vulnerable settlements, with clear criteria for inclusion/exclusion.	A cross-sectional study was used with appropriate methods to collect data through structured interviews and validated questionnaires; an appropriate statistical analysis to determine associations.	The prevalence of diarrhoea in children under five was 29%. Significant associated factors include: - Regular household cleanliness (AOR: 2.13). - Drinking water source (AOR: 2.36) - Access of animals to water storage (AOR: 3.04) - Presence of vectors near food storage (AOR: 9.13) - Use of food leftovers (AOR: 4.31) - Faecal contamination of water (AOR: 12.56)	7/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Moreno et al. (36)	Cerro Guy de Lambaré Community (Paraguay)	To describe skin pathologies in children living in shelters in flooded areas.	Cross-sectional descriptive study	Children living in flood shelters; inclusion and exclusion criteria are clear.	An observational descriptive study of paediatric patients with skin pathologies seen in the Cerro Guy de Lambaré community in July 2014.	100 paediatric patients were seen. Impetigo (16%) and pediculosis capitis (36%) were the most frequent pathologies. Other dermatoses were scabies, ringworm, xerosis, tinea corporis. 56% of the patients were female and the most affected age group was children under 6 years of age. 94% of the patients consulted a doctor for pruritus. The onset of the lesions in 82% of the patients coincided with the time they moved to their current shelter (1 month). Of the patients affected with scabies and pediculosis, 74% had paediatric cohabitants with the same pathology.	7/8
Musacchio et al. (38)	Ireland	To explore perceptions and behaviours related to risks associated with flooding and water pollution in Ireland.	Cross-sectional study	Residents in Ireland with different levels of exposure and perception of environmental risk related to water and flooding.	Validated questionnaires to collect data on perception and behaviour; appropriate statistical analysis to assess associations.	Floods are not considered likely or a cause for concern; 72.5% who experienced previous floods did not take protective measures. However, previous experiences with pollution increased proactive attitudes (+47%).	7/8
Becquart et al. (13)	Louisiana	To analyse how Hurricane Katrina affected hospitalisation rates for cardiovascular disease in the elderly.	Retrospective observational study	Elderly people in Louisiana parishes, with specific criteria for inclusion.	A retrospective analysis of hospital data before, during and after the hurricane was used, a method appropriate for this type of study.	In Orleans Parish, directly affected by the hurricane, hospitalisation rates peaked on the sixth day after the event with an increase (mean ± SD) from 7.25 ± 2.4 to 18.5 ± 17.3 cases/day per 10,000 adults aged 65+ ($p < 0.001$) and returned to the pre-event level after ~2 months. Disparities in CVD rates between black and white elderly adults were exacerbated during and after the event. In Orleans Parish, one week after the eventl, CVD rates increased to 26.3 ± 23.7 and 16.6 ± 11.7 cases/day per 10,000 persons ($p < 0.001$) for both black and white patients, respectively.	7/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Sunohara et al. (32)	Nagano (Japan)	To determine the relationship between Typhoon Reiwa flooding and cardiovascular and cerebrovascular events in Nagano, with a clear hypothesis.	Observational study	Residents in Nagano affected by Typhoon Reiwa.	The Shinshu Assessment of Flood Disaster Cardiovascular Events (SAVE) study was conducted, including 2,426 patients admitted for cardiovascular or cerebrovascular diseases at five different hospitals in Nagano from October to December in 2017, 2018 and 2019. Occurrences were compared every 2 weeks, focusing on 2019 (flood year) versus previous years.	- Cardiovascular and cerebrovascular diseases increased significantly in the two weeks after the disaster (149 cases in 2019 vs. average of 116.5 in previous years; $p<0.05$). - Cases of unstable angina increased between 1.5 and 2 months after the disaster. - Cerebral haemorrhages increased markedly in the two weeks after the flood.	7/8
Oluyomi et al. (14)	Houston	To assess allergic symptoms and stress following flooding due to Hurricane Harvey.	Observational study	Houston residents who were affected by flooding caused by Hurricane Harvey in 2017. More specifically, participants were adults living in flood-impacted areas who participated in surveys or interviews to assess allergic symptoms and stress levels related to the disaster.	The study used a cross-sectional design with structured surveys to collect data on allergic symptoms and stress levels in adults living in Houston affected by Hurricane Harvey flooding.	The main findings were that people affected by the floods had an increase in allergic symptoms and stress levels, showing a negative impact on their physical and mental health after the event.	7/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Aneelraj et al. (33)	Uttarakhand (Himalayas)	To analyse psychosocial adversities in children and adolescents in the aftermath of the Uttarakhand disaster in 2013.	Observational study	The sample included children and adolescents affected by the disaster. 300 children with a mean age of 11.5 years were examined; 65 (32.5%) were boys. Two hundred (66.7%) children/adolescents reported some psychosocial adversity attributable to the disaster.	This cross-sectional observational study was conducted by the National Institute of Mental Health and Neurosciences (NIMHANS), Bangalore, in the first month after the Uttarakhand disaster in 2013. A multidisciplinary team comprising a psychiatric resident, a clinical psychologist, a psychiatric social worker and a nurse conducted the community-based assessments and interventions in the population affected. Clinical assessments were conducted using the International Classification of Diseases 10 (ICD-10) to establish psychiatric diagnoses. Data collected was analysed using descriptive statistics and chi-square tests to identify significant associations between socio-demographic variables and psychosocial conditions or diagnoses.	Psychological distress was present in 54 of the 300 subjects (18%). Loss of shelter and play space showed a statistically significant association with signs of psychological distress such as anxiety, helplessness, insecurity, pain and uncertainty. No stress-induced psychiatric disorders were diagnosed in the children or adolescents; however, stress-related psychiatric symptoms were present in approximately 13% of them.	7/8
Dai et al. (25)	China	To estimate the prevalence of PTSD and anxiety among flood survivors 17 years after the 1998 Dongting Lake flood and to identify risk factors for PTSD and anxiety.	Cross-sectional study	325 participants, survivors from the areas most affected by the flooding	Survivors from the most flood-affected areas were included through stratified systematic random sampling. Highly skilled researchers conducted face-to-face interviews with participants using the PTSD Checklist (civilian version), the Zung Anxiety Self-Assessment Scale, the Chinese version of the Social Support Assessment Scale and the Eysenck Personality Questionnaire Revised (short scale for Chinese) to assess PTSD, anxiety, social support and personality traits, respectively. Logistic regression analyses were used to identify factors associated with PTSD and anxiety.	The prevalence of PTSD and anxiety was 9.5% and 9.2%, respectively. Multivariate logistic regression analyses showed that the female gender, experience of at least three flood-related stressors, a low level of social support, and emotional instability were risk factors for adverse long-term psychological consequences among post-disaster flood survivors.	8/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Deng et al. (15)	New York	To research the effects of floods and power cuts on public health	Analytical observational study.	New York State hospitalisation rates (from 2002 to 2018), affected by power outages.	Data used: hospitalisation data from New York State, power outage data from the State Department of Public Utilities, and floods reported by the NOAA were used. Statistical Models: nonlinear distributed lag models were used to assess associations between PO/floods and health, checking for confounding factors.	High Risks: Co-occurrence of PO and flooding showed the highest coefficients for rates (R), followed by PO alone and then flooding alone. Immediate effects were observed for chronic respiratory diseases (R: 1.58) and FWBD (R: 3.02). Delayed effects were found for cardiovascular diseases (lag 3, R: 1.13) and respiratory infections (lag 6, R: 1.85). Groups Affected: the association was slightly more evident among women, whites, older adults and the uninsured, although not in a statistically significant way.	7/8
Peden et al. (29)	Australia	To understand flood-related behaviour among river users in Australia	Qualitative study	688 river users	Self-administered interviews and surveys of river users in different regions in Australia.	35.7% reported driving through flood waters and 18.7% reported swimming in a river during a flood. Men were significantly more likely to have done both activities ($p<0.001$). Australian-born respondents were more likely to have driven in flood waters ($p=0.006$). Young people aged 18-24 and those living in remote regions were also more likely to swim in rivers during floods ($p<0.001$). Those who had engaged in this behaviour were also more likely to record significant alcohol levels (BAC ≥0.05%) ($p=0.001$ for driving and $p<0.001$ for swimming).	7/10
Mekuyie et al. (31)	Lokka Abaya District, Sidama, (Ethiopia)	To assess household vulnerability to climate-induced upset and stress	A quantitative, cross-sectional, descriptive-analytical study.	258 smallholder farmers through stratified random sampling.	Household surveys, focus group discussions and key informant interviews. - Indicators: social, economic and environmental indicators were used to draw up a vulnerability index based on adaptive capacity, exposure and sensitivity.	Limited Access to Services: farmers have little access to affordable credit, markets, health services and climate information. Climate Challenges: droughts, floods, soil erosion, pests and diseases are significant problems. Household Vulnerability: Highly vulnerable: 8.5% of male-headed households and 18.2% of female-headed households. Moderately vulnerable: 41% of men and 45.5% of women. Less vulnerable: 37.7% men and 27.3% women. Not currently vulnerable: 12.8% of men and 9% of women.	7/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Mızrak and Turan (34)	Gümüşhane, (Turkey)	To address people's readiness to relocate due to natural disasters, more specifically floods and landslides, in Gümüşhane province (Turkey).	Quantitative, cross-sectional, analytical study	947 residents of Gümüşhane were surveyed.	Ordinal logistic regression models were used to assess the correlations between the variables studied and the willingness to relocate.	Greater willingness to relocate due to landslides: participants showed a greater willingness to relocate due to landslides compared to floods. Factors increasing willingness to relocate: university students and people with chronic illness or previous disaster experience showed greater willingness to relocate. Perception of risk was influenced differently by the type of disaster: For floods, perception of likelihood increased willingness to relocate. For landslides, fear was the most influential factor. Factors decreasing willingness to relocate: longer duration of residence in an area and a high level of informal social support were associated with a lower willingness to relocate. Self-efficacy: Contrary to expectations, those who believed they could protect themselves in the event of a disaster were more willing to relocate.	7/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Adams et al. (16)	USA	To assess mortality rates in this population, more specifically those related to forces of nature (such as hurricanes, storms, floods, etc.).	A quantitative, retrospective, observational study.	Older adults (aged 65 and over), grouped together by race/ethnicity and gender.	Mortality registry data and descriptive and comparative statistical methods were applied to assess mortality rates and their differences according to race/ethnicity and gender.	Impact on older adults From 1999 to 2017, there were 9,039 deaths from natural forces among people aged 60-84. This implies a gross mortality rate of 0.945 per 100,000 people. Older adults had a mortality rate 3.84 times higher than those under 60 years of age. By gender Older men: 5,604 deaths Rate: 1.288 per 100,000 Older women: 3,435 deaths Rate: 0.659 per 100,000 Older men had almost twice the mortality of older women. By race/ethnicity American Indian/Alaska Natives: Highest rate: 4,220 per 100,000 Blacks: Second highest rate: 1,909 per 100,000 Whites: Rate: 0.843 per 100,000 Latinos: Rate: 0.598 per 100,000 Asian/Pacific Islanders: Lowest rate: 0.248 per 100,000	7/8
Zhong et al. (24)	Anhui (China)	To draw up and validate indices of health vulnerability and adaptive capacity to extreme weather events, using the 2016 floods in Anhui Province, China, as a case study.	Quantitative, cross-sectional, ecological study.	Municipalities and rural and urban communities in Anhui Province, China.	Composite vulnerability and adaptation indices were constructed using demographic, social, health and environmental indicators. Statistical methods such as principal component analysis (PCA). Validation using post-flood health impact data (morbidity, mortality, displacement).	Vulnerability. High in regions with ageing population, low education and limited access to health services. Adaptive capacity. Better conditions in areas with a well-developed health infrastructure, early warning systems and greater community participation. Validation. The vulnerability index correlated significantly with greater health impacts following floods.	7/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Tauzer et al. (35)	Machala (Ecuador)	To study vulnerability to floods through a participatory approach	Qualitative study	Focus groups (n = 11) with community members (n = 65 people)	Focus groups were held with 65 community members in flood-prone peri-urban areas in Machala, Ecuador. Participatory mapping and GIS software were used to assess perceptions of flood exposure and adaptive capacity. Qualitative data was triangulated with historical government information.	- Flooding associated with seasonal rainfall, El Niño, high tides, blocked drainage and low elevation. - Maps revealed spatial heterogeneity in perceived risk; ten areas of particular concern identified. - Sensitive populations include children, the elderly, people with disabilities, low-income families and recent migrants. - Impacts include damage to property and infrastructure, power outages and infectious disease outbreaks. - Limited adaptive capacity due to lack of social organisation, political commitment and financial capital.	8/10
Hua et al. (17)	Houston, Texas (USA)	To assess excess all-cause mortality among NH residents associated with Hurricane Harvey, and to explore how mortality varies between short- and long-stay residents, as well as by chronic disease.	Retrospective observational cohort or cross-sectional epidemiological study.	Residents of nursing homes in the region during or after the event.	We compared 30-day and 90-day mortality between residents exposed to Hurricane Harvey in 2017 and those not exposed over the previous two years. Data was obtained from the Minimum Data Set Assessments and the Medicare Beneficiary Summary File. Linear probability models adjusted for demographics, clinical acuity and NH fixed effects were used. Analyses were stratified by short- and long-stay status.	In 2017, 18,479 residents were exposed to Hurricane Harvey. No significant association was found between hurricane exposure and 30-day mortality. However, at 90 days, there was a significant increase in mortality among long-stay residents (7.6% in 2017 versus 6.3% in 2015). This increase was particularly notable among residents with chronic obstructive pulmonary disease (COPD), where mortality was 9.2% compared to 7.2% in 2015.	6.5/8
Heslin et al. (18)	USA	To analyse how hurricanes affect the use of emergency services in different regions impacted by these storms in the USA.	Retrospective observational study	Residents of 344 counties after the occurrence of 7 hurricanes in the USA from 2005 to 2016. 88 million people.	Emergency Department data from the State Inpatient Databases of the Health Care Cost and Utilisation Project and the State Emergency Department Databases was used. ED use rates for weeks during and after the hurricanes were compared to pre-hurricane rates, stratified by proximity of the patient's county to the hurricane path, age and disease category.	The rate of weekly emergency department visits in the general population changed shortly after the hurricane, but rates by disease category and age showed mixed results. Utilisation rates for respiratory disorders showed the greatest increase after the hurricane, particularly 2-3 weeks after the event. The change in rates by disease category and age tended to be greatest for persons residing in counties closest to the hurricane's path.	6/8

Studies	Context	Goal of the study	Type of study	Participants	Methods	Main findings	Quality
Khan et al. (27)	Pakistan	To assess the impact of the 2022 floods on the socio-economic status and health of people living in flood-affected areas in Pakistan.	Cross-sectional Descriptive Study	811 participants	A post-flood survey was conducted in three different districts of Pakistan, using a validated questionnaire to collect data on biopsychosocial aspects of the community affected. The data was analysed using SPSS version 25.	Of the 811 participants, 696 (85.8%) were male and 113 (13.9%) female; two did not disclose their gender. The majority were in the 30-40 age group (35%). Geographically, the largest number came from the Swat district (58.9%). In terms of occupation, 63.6% were labourers. The socio-economic impact showed a significant decrease in monthly income after the floods ($p = 0.03$). A total of 48.7% lost their main source of income due to the disaster. In terms of health, 83.4% reported post-flood illnesses; diarrhoea (42.6%), malaria (29.7%) and cholera (10%) were the most common.	6/8
Lieberman-Cribbin et al. (19)	New York (USA)	To analyse the unequal burden of flooding on New York City residents after Hurricane Sandy, assessing whether the distribution of risk was equitable according to socio-demographic characteristics.	Cross-sectional observational study (ecological)	1,231 participants	Self-administered survey conducted 1.5 to 4 years after the event, with 1,231 participants from New York and Long Island. Multivariate logistic regressions were used to analyse the relationship between sociodemographic variables and flood exposure.	Areas with lower middle incomes (<$40,298 and $40,298-$67,188) showed higher frequency of flooding (FEMA/self-reported: 65.3%/42.0% and 43.3%/32.1%). These areas had higher proportions of non-white residents and people with a high school education or less. Older people were more likely to live in households exposed to flooding. Areas with higher incomes were less likely to flood ($p < 0.0001$).	8/8

Prepared by the author. For inclusion in this review, a minimum cut-off point of 6 points was established. Studies that met this threshold were considered methodologically suitable. A traffic light visual assessment of the methodological quality of the included studies was established (32).

JBI methodological quality assessment of cross-sectional observational studies

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Score
Liu et al. (40)	Green	Yellow	Green	Green	Yellow	Green	Green	Yellow	6.5/8
Colston et al. (37)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Ding et al. (20)	Green	Yellow	Green	Green	Yellow	Green	Green	Yellow	6.5/8
Luo et al. (21)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Mavroulis et al. (39)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Saeed et al. (26)	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	6.5/8
Adekunle et al. (28)	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	6.5/8
Lynch and Chaman, (12)	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	6.5/8
Zhang et al. (22)	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	6.5/8
Liao et al. (23)	Green	Green	Green	Green	Green	Green	Green	Yellow	6.5/8
Birhan y Bitew (30)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Moreno et al. (36)	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	6.5/8
Musacchio et al. (38)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Becquart et al. (13)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Sunohara et al. (32)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Oluyomi et al. (14)	Green	Green	Green	Green	Yellow	Green	Green	Yellow	7/8
Aneelraj et al. (33)	Green	Green	Green	Yellow	Green	Yellow	Green	Green	7/8
Deng et al. (15)	Green	Green	Green	Green	Yellow	Yellow	Green	Yellow	6.5/8
Mekuyie et al. (31)	Green	Green	Green	Green	Yellow	Yellow	Green	Green	7/8
Mızrak and Turan (34)	Green	Green	Green	Green	Yellow	Yellow	Green	Green	7/8
Adams et al. (16)	Green	Green	Green	Green	Green	Yellow	Green	Green	7.5/8
Zhong et al. (24)	Green	Green	Green	Green	Yellow	Yellow	Green	Green	7/8
Hua et al. (17)	Green	Green	Green	Green	Yellow	Green	Green	Red	6.5/8
Heslin et al. (18)	Green	Green	Green	Green	Green	Red	Green	Red	6/8
Khan et al. (27)	Green	Green	Green	Green	Red	Red	Green	Green	6/8
Lieberman-Cribbin et al. (19)	Green	Green	Green	Green	Green	Green	Green	Green	8/8
Dai et al. (25)	Green	Green	Green	Green	Green	Green	Green	Green	8/8

Items: 1. Participants and setting described in detail. 2. Inclusion criteria clearly defined. 3. Valid and reliable measurement of exposure. 4. Objective measurement of condition. 5. Identification of confounding factors. 6. Strategies for dealing with confounding factors. 7. Validly measured results. 8. Appropriate statistical analysis.

JBI methodological quality assessment of qualitative studies

	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Item 9	Item 10	Score
Peden et al. (29)											7/10
Tauzer et al. (35)											8/10

Items. 1. Congruence between philosophical perspective and methodology. 2. Congruence between methodology and question or goals. 3. Congruence between methodology and data collection. 4. Congruence between methodology and data analysis. 5. Congruence between methodology and interpretation of results. 6. Cultural and theoretical positioning of the author. 7. Reflection on researcher influence. 8. Representativeness of participants. 9. Documented ethical approval. 10. Conclusions related to the data.

Legends: green: "yes" answers (J), yellow: "unclear or not applicable" (K), red: "no" answers (L).

Search strategy

Databases	Search strategy	Results	Filters applied
PubMed	(("disaster*[Title/Abstract] OR "flood*"[Title/Abstract] OR "tsunami"[Title/Abstract] OR "Stream"[Title/Abstract]) AND "disease*"[Title/Abstract] AND "mud"[Title/Abstract]) AND (2014/1/1:2025/3/1[pdat])	8	Timespan: 2014-01-01 to 2025-03-01 (Publication Date)
Scopus	(TITLE-ABS-KEY (disaster* OR flood* OR tsunami OR stream) AND TITLE-ABS-KEY (disease*) AND TITLE-ABS-KEY (mud)) AND PUBYEAR > 2013 AND PUBYEAR < 2026	30	Last 11 years, Article
WoS	Disaster* OR flood* OR tsunami OR Stream (Topic) AND disease* (Topic) AND mud (Topic)	73	Timespan: 2014-01-01 to 2025-03-01 (Publication Date) Open Access articles
TOTAL		**111**	
Last search on 21 April 2025			

Prepared by the author.

ANNEX 3
RADIOGRAPHY OF THE COLD DROP (29/10/2024)

INTEGRATED SUMMARY OF THE COLD DROP	
Accumulated rainfall	Rainfall intensity (accumulated): *Very heavy*: 30-60 mm in 1 h *Torrential*: > 60 mm in 1 h *Persistent*: > 100 mm in 12 h **Areas with ≥ 100 mm accumulated** in 12 h: Málaga, Granada, Murcia, Albacete, Cuenca and Valencia **National records in Valencia** (Turís station): *Maximum in 1 h*: 185 mm (3x the torrential threshold, 60 mm/h), +26 mm previous hourly maximum (159 mm, Vinaròs, 19/10/2018) *Maximum in 6 h*: 621 mm (2x the previous most extreme record - 310 mm at Alpandeire, 21/10/2018) *Maximum in 12 h*: 720 mm (2x the previous highest record - 360 mm at Alpandeire, 21/10/2018) (See Figure 8)
Hydrological data	**Rambla del Poyo**: Flow of more than 2,200 m³/s (~5 times the flow of the Ebro in Zaragoza: 461 m³/s). **Forata Dam**: Reached a height of 379.20 m (nominal height: 384 m). Releases at 30 m³/s were required; a peak of 1,111.44 m³/s in the River Magro. **River Magro**: Overflow in the Ribera Alta, which affected municipalities such as Algemesí and Carlet.
	232 **deaths** (224 in Valencia Region, 7 in Castilla La Mancha and 1 in Andalusia), 3 **missing** (until 12 Jan 2025), >50 % ≥ 70 years old (15 > 90 years old; 9 minors), 26 foreigners (11 nationalities)
Casualties	**Municipalities affected**: 90 (1,910,461 inhabitants) '**Ground Zero**': 15 (269,695 inhabitants) (See Figure 8)
Demographic data	**Estimated losses**: €22 billion, 66,000 businesses affected **Reverse effect on GDP**: –0.1 to –0.2 pp in Q4 2024
Overall economic impact	**Agriculture** (€1,020M): 33,728 ha heavily damaged, 175,000 ha damaged, 50,000 plots of land destroyed, 10,000 farmers; crops affected: citrus, persimmon, vegetables, rice, nurseries and vineyards. **Industrial** (€4,503M): machinery (€1,215M), vehicles (€1,127M), metal and electrical (€1,210M), furniture and wood (€316M), chemical-plastic (€277M), agri-food (€265M), other manufacturing (€92M). **Transport** (€2,189M), **Construction** (**€**3,813M) **Retail** (€1,789M)
Sectoral damages	**Flooded homes located**: > 130,000 **Ground zero**: 113,443 homes **Declared uninhabitable**: 1,500 possible **Demolition order**: 305 homes **Data from the Insurance Compensation Consortium**: 48,003 homes damaged (only includes insured homes) **SAREB homes**: has made 177 homes available for those affected. In addition, the government has rented others.
Infrastructures and vehicles	**Roads**: 7 motorways, 3 national and 18 regional roads damaged. **Vehicles destroyed**: 120,000; compensation claimed 138,712 (55,648 paid, i.e. €482.2M). REPLACE CAR Plan and aid of up to €2,500 per vehicle (€465M).

Health and mental health	**Health centres**: 57 affected (23.4%); 53 operational, 10 under repair; 15 clinics with limitations. **Volunteers**: 20,000 (5,000 from the Health Service in Valencia). **Psychosocial assistance**: 30 professionals, 10 consultations, 2 ambulances, 110 health workers, 17 teams; 230 people assisted. **Supplies of PPE**: 800,000 masks, gloves and protectors. **Health activity**: 511,000 prescriptions renewed, 268,000 prolonged treatments; 2 probable cases of leptospirosis; 2,017 patients on oxygen therapy.
Waste and water	**Solid waste**: 400,000 t removed; 1 local collection point, 5 transfer points; sludge (Picassent, Manises) and hazardous waste management; exemption from fees. **Wastewater treatment plants**: €100M investment for 123 installations; 100% operational from 12 Dec; exemption of the levy (~25 M€) until Feb 2025; 125 sludge trucks; 121 unblocking machines; > 750 staff. **€20M aid** for irrigation associations.
Air quality and mapping	4 mobile stations in l'Horta Sud for PM and sludge dust. New cartography Nov. 2024 (Turia, Magro, Poyo embankment); interactive street-by-street map (UPV).
Biodiversity and environment	**L'Albufera Plan**: barrier phases, unblocking of irrigation ditches, removal of waste and improvement of reserves. **Turia Natural Park**: cleaning and waste removal (€21.5M). **Buseo dam**: structural repair (€4.8M, 12 months).
Social services and inclusion	**Teleassistance**: 387,878 calls. **Valencia Inclusion Income**: 1,670 applications. **Dependency**: 5,397 benefits resolved; 2,636 reviews. **Disability**: 200 examinations; 14 relocations in residences. **Investment**: €2.2M for social centres; €1M for the tertiary sector.
Recommendations	**Quantification and follow-up**: Prioritise net magnitudes rather than gross GDP. Create a post-DANA observatory (special unemployment benefits, energy consumption, geo-referenced data). **Financial support and aid**: Speed and proportionality in public transfers. Indispensable state support in the face of regional limitations. **Recovery and modernisation**: Take advantage of reconstruction to increase productivity and modernise sectors. Clear roadmap and defined deadlines to give confidence. **Reduction of future risks**: Review land use and urban planning regulations. Encourage preventive investments (water infrastructure, organisational capital, civic education). **Attention to inequality**: Design sectoral aid according to impact (e.g. special unemployment benefits > 30 % at ground zero). Reinforced protection for vulnerable groups (elderly, self-employed, SMEs).

Prepared by the author.

Source: AEMET. Report on the meteorological episode of torrential and persistent rainfall caused by a DANA (cold drop) on 29 October 2024. Department of production, production and infrastructure directorate AEMET. [Internet] 2024. [Accessed 28 Mar 2025].

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