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Public health implications of multiple disaster exposures

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Disasters are an important public health issue; however, there is scarce evidence to date on what happens when communities and populations experience more than one disaster. This scoping review identifies literature on the effects of multiple disasters published until Aug 2, 2021, 1425 articles were identified, of which 150 articles were included. We analysed direct and indirect public health implications of multiple disasters. Our analysis suggests that exposure to multiple disasters can affect mental health, physical health, and wellbeing, with some evidence that the potential risks of multiple disaster exposure exceed those of single disaster exposure. We also identified indirect public health implications of multiple disaster exposure, related to changes in health-care facilities, changes in public risk perception, and governmental responses to multiple disasters. We present findings on community recovery and methodological challenges to the study of multiple disasters, and directions for future research.

Introduction

Disasters can lead to short-term and long-term effects on physical and mental health, and can indirectly affect health and wellbeing as a result of evacuation, social disruption, financial loss, lifestyle change, damage to health-care facilities, and changes to the wider political and socioeconomic context.^{1,2} Historically, disasters have been considered as rare, singular, discrete events. However, in the past 10 years, there has been increasing recognition of the ways in which disasters can overlap.^{3,4} In March, 2011, the northeast region of Japan experienced the Great East Japan Earthquake, which led to a tsunami and subsequently to a nuclear disaster—an event that is often referred to as the 3.11 triple disaster.³ In 2017, Hurricane Harvey resulted in a chemical plant explosion in Texas, USA, in addition to flooding and fires.⁵ There are many examples of multiple disaster events occurring together, and the past year highlights overlaps between the COVID-19 pandemic and other types of disaster globally.^{4,6} In the context of projected increases in disasters as a result of climate change,^{7–9} and already high frequencies of exposure to overlapping disasters, there is a need to understand the ways in which multiple disasters can affect population health, wellbeing, and recovery processes, and the extent to which these effects might differ from those of single disasters.

In the past 5 years there has been a growing body of theoretical and conceptual work to understand so-called cascading disasters (disasters generating secondary disasters), compound disasters (combinations of simultaneous or successive extreme hazard events), and recurrent disasters (in which the same hazard repeats; table).^{10–16} However, unclear and inconsistent terminology is often used to describe multidisaster scenarios,^{5,14–16} and wider understanding of the public health effects of these events is poor. The literature on cascading or compound disasters is often primarily focused on modelling risks and hazards and on the role of critical infrastructure,⁵ whereas empirical research, especially on community-level or population-level effects and on long-term recovery processes, has been scarce. The extent of the literature on the public health implications of multiple disasters has been unclear.

In this scoping review we aim to identify empirical research on the public health effects of the exposure of individuals or communities to multiple disasters, and recovery from these events. We draw on the definition from the United Nations Office for Disaster Risk Reduction of a disaster as a “serious disruption of the functioning of a community or a society at any scale due to hazardous events interacting with conditions of exposure, vulnerability and capacity, leading to one or more of the following: human, material, economic and environmental losses and impacts.”¹⁷ When examining the public health implications of multiple disasters, we take an inclusive view as to what qualifies as a disaster. We build from work in disaster studies identifying the importance of accounting for not only the commonly recognised ‘natural’ and technological disasters, but also slow-onset disasters such as drought,¹⁸ chronic disasters,¹⁹ and neglected disasters that have received less attention because they are misunderstood or they do not fit into the clear categories of ‘natural’ or technological.²⁰ We approach this Review with recognition that all these disasters have the potential to co-occur, occur sequentially, or repeat, and we seek to identify existing literature on cases in which people or communities have experienced more than one disaster. The focus of this Review is on public health effects and the recovery process from past events, while recognising that exposure to multiple disasters can involve overlapping periods of preparedness, response, and recovery.

Methods

Through this scoping review we examined the extent, range, and nature of research activity²¹ on multiple disasters, public health, and recovery. We sought to include any empirical public health literature on previous cases of cascading, compound, or recurring disasters; however, considering the inconsistencies in terminology noted in previous papers, we also left scope to include multiple disaster scenarios that have been researched but not labelled in these ways. Our research questions, therefore, focus on multiple disasters rather than specifying disasters as cascading, compound, consecutive, or recurring. With a focus on identifying and

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	Definition	Example
Consecutive disasters	“Two or more disasters that occur in succession, and whose direct impacts overlap spatially before recovery from a previous event is considered to be completed.” ¹⁰ This definition includes successive compound disasters and cascading disasters. ¹⁰	In 2008, Haiti was hit by multiple hurricanes. While still in the process of recovering from the hurricanes, Haiti then experienced a magnitude 7 earthquake in 2010 and a subsequent outbreak of cholera. These disasters have been labelled as consecutive disasters. ¹⁰
Compound disasters	A term to describe natural hazards and the combination of two or more extreme events, which occur simultaneously or successively and have substantial effects. ^{11,15}	In 2012, Hurricane Sandy hit the New York metropolitan area. The unusual path of Hurricane Sandy was affected by multiple weather systems over the North American continent and the north Atlantic. This combination of multiple climate hazards, culminating in an unusual hurricane path and subsequent intense effects (widespread flooding), is referred to as a compound event. ¹⁵
Cascading disasters	“Extreme events, in which cascading effects increase in progression over time and generate unexpected secondary events of strong impact. These tend to be at least as serious as the original event, and to contribute substantially to the overall duration of the disaster’s effects.” ¹³ A key element to cascading disasters is that they have a point of escalation, a crucial junction in a chain of reactions that leads to greater effects than the initial disaster would have done. ¹² Cascading hazards, risks, and disasters have gained increasing attention since 2010. ^{3,12,15}	The 3.11 triple disaster in Japan in 2011 (earthquake that led to tsunami, which then led to nuclear disaster) is often described as a cascading disaster. ³
Recurring or recurrent disasters	“The recurrence of a single natural hazard in the same geographic region over a one-year period.” ¹⁶	There was severe flooding in Pakistan in 2010, 2011, and 2012. Haiti experienced four hurricanes in 2008. These are two examples of recurring disasters. ¹⁶

Table: Terminology to describe multiple disasters

collating learnings from past events, we constrained the focus of this Review to empirical studies from contexts in which people or communities had been previously exposed to more than one disaster. Specific inclusion terms are presented below. We followed the scoping review methodology outlined by Arksey and O’Malley,²¹ and the principles for reporting in the PRISMA Extension for Scoping Reviews (appendix p 29).²²

See Online for appendix

The following research questions were developed through preliminary literature searches and discussions with colleagues: what research has been done to examine the complexities of the public health effects of multiple disasters, and what research has been done to examine experiences of recovery from multiple disasters?

Data abstraction and content analysis

We abstracted data on publication information, study sites, multiple disaster constellation covered, methods, key findings, and any recommendations made in articles. We also noted if and how recovery was discussed, and detailed methodology information for studies on quantitative health outcomes.

We inductively created categories based on primary areas of focus (ie, mental health, physical health, etc). We then analytically grouped articles on the basis of their key themes into whether they covered direct or indirect implications for public health, informed by the framework outlined by Shoaf and Rottman.¹ Deaths, illnesses, and physical and psychological effects of multiple disasters were classified as direct implications, and any wider factors that could influence population health in multiple disasters were classified as indirect implications for public health.

Reflecting on the literature on methodological challenges to the study of (singular) disasters,²³ we also assessed articles for any methodological or conceptual challenges that were explicitly noted or implicitly apparent in relation to the study of multiple disasters.

Results

The 150 included articles (figure 1) were published between 1994 and 2021. Most of these articles (111; 74%) were published in or after 2014, highlighting that the public health implications of multiple disaster exposures is an emerging area of research. The articles covered a range of hazard constellations, and the lengths of time between each disaster ranged from minutes to years; the longest specified time between disasters was 25 years between the Good Friday earthquake and tsunami and the Exxon Valdez oil spill in southcentral Alaska, USA.²⁴ Some disasters were studied more frequently than others. One of the largest groups of articles focused on combinations of hurricanes—including some or all of Katrina in 2005, Rita in 2005, Gustav in 2008, Ike in 2008, and Isaac in 2012—and the Deepwater Horizon oil spill (2010) in the Gulf Coast of the USA (19 articles).^{25–43} A further ten articles focused on some or all of these hurricanes but not on the oil spill.^{44–53} Of all included articles, 71 (47%) covered cases of recurring disasters.^{30,31,34,37,38,43–51,54–84} The full list of disaster cases covered in the included articles can be viewed in the appendix (p 1).

Most of the 150 included articles had a quantitative research design (98; 65%), with fewer qualitative (42; 28%) or mixed methods (10; 7%) studies. We present a detailed assessment of 67 quantitative health outcome studies in

the appendix (p 18); the majority (53; 79%) were cross-sectional studies with no comparison groups and sample sizes ranging from 100 to 5000. There were ten major population studies with more than 10 000 participants and ten studies that included comparison groups, whereas five studies had fewer than 100 participants.

We categorised articles on the basis of their primary topic of focus by frequency (figure 2). The following sections outline the identified direct and indirect implications for public health and the recovery process, and methodological challenges.

Direct implications for public health

Mental health

More than a third of included articles (53; 35%) focused on mental health in the aftermath of multiple disasters,^{25–30,32,35–37,41,46,48,51,54,56–58,63,64,71,72,84–114} representing the largest theme identified. Numerous articles observed high rates of psychological distress, acute stress disorder, post-traumatic stress disorder, depression, panic disorder, or risk of suicide attempts in populations that had experienced multiple disasters.^{36,54,56,64,84,90,93,97,98,110,112,114}

There were different approaches to study multiple disasters and mental health. Some studies compared the mental health risks from multiple (more than one) disaster exposures with the risks from a single disaster exposure, and found that multiple exposures were associated with increased risks to mental health (a cumulative effect).^{37,41,46,71,85,97,98,109} For example, in a nationally representative survey of Australians, those exposed to multiple disasters across their lifetime were at significantly greater risk of suicide attempts than were those exposed to a single disaster.⁹⁸ Although some researchers have questioned whether exposure to one disaster could have a positive effect of preparing people mentally for future disasters, we identified evidence against this notion.^{37,46,98} For example, Harville and colleagues⁴⁶ found that exposure to both Hurricane Katrina and Hurricane Gustav was associated with poor mental health, and that even when individuals perceived benefit after the first disaster, this benefit was not protective against the mental health effects of experiencing both disasters. Conversely, one study after the 9/11 terrorism attack (2001) and Hurricane Sandy (2012) found that previous high exposure to the 9/11 terrorism attack was associated with a weaker effect of Hurricane Sandy on post-traumatic stress disorder for older adults, but the opposite result was found for younger adults.⁸⁹ These findings represent an area in need of further study; however, from the articles identified in this Review, there were no consistent findings to suggest that experiencing one disaster could be protective against the effects of the next.

A group of studies found that mental health outcomes differed according to the severity of multiple disaster exposures (defined by one or more of degree of losses, damage, difficulties in accessing resources, perceived

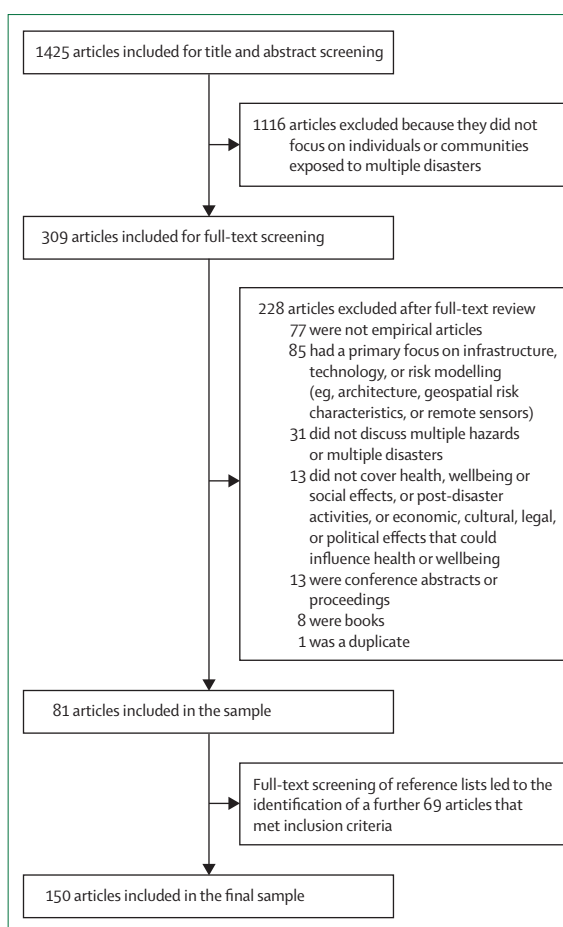


Figure 1: Flow chart of included studies

danger, or injuries experienced; appendix p 18).^{46,64,100,105,106} Another subset of articles focused on the mental health of children who had experienced multiple disasters,^{28,32,87,107,113} and found both cumulative effects and differences according to the severity of exposures. Another group of studies found that post-traumatic stress disorder from previous disasters can be exacerbated or reactivated after experiencing the next disaster, even if it is a different type of disaster. This occurrence was highlighted by studies that looked at populations exposed to both the 9/11 terrorism attacks and Hurricane Sandy in New York.^{89,92,94,100,102,106}

Other articles on mental health included a group of studies that focused on the identification of socio-demographic characteristics associated with increased risk of adverse mental health outcomes following multiple disasters (eg, by age,^{48,51} gender, educational attainment, financial hardship,^{35,57} and temporary housing experiences¹¹¹), with mixed results. Another group of articles focused on mental health risks faced by disaster responders^{86,103,104} and public health workers^{62,64} in the face of multiple disasters. There was also a group of studies that described alcohol-related and tobacco-related

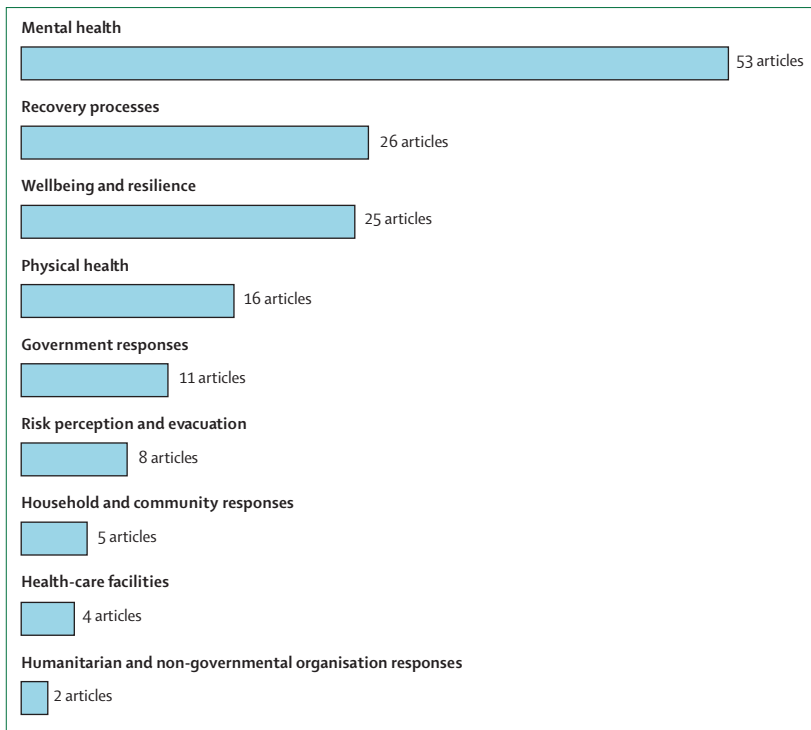


Figure 2: Included articles by primary topic of focus (n=150)

health behaviours and mental health in the aftermath of multiple disasters.^{64,95,96,99,101}

Wellbeing and resilience

25 studies focused on factors influencing wellbeing and resilience in settings of multiple disasters,^{31,33,34,38–40,42,44,45,47,49,50,55,62,68,77,82,83,115–121} including religiosity and the role of religion on coping,^{38,40,45,47,49} social support,⁴⁵ the will to live,¹¹⁶ gender,⁴⁵ perceived collective efficacy,^{115,120} and perceived communal coping,¹¹⁹ with mixed findings across different disaster contexts. One subset of articles focused on identifying patterns in positive emotions and post-traumatic growth following multiple disasters,^{33,42,50,55,83,117,120} with some studies highlighting that hope and optimism³³ or psychological resilience⁴² can be protective factors for mental health after multiple disasters or can facilitate coping and resilience after multiple disasters.⁵⁰ More widely, wellbeing and resilience have generally been insufficiently studied following multiple disasters. One systematic review that focused on the 3.11 triple disaster in Japan found numerous studies documenting mental health effects, although little research on the resilience of this population or on possible interventions to support wellbeing.¹¹⁰

Turning to barriers to wellbeing or resilience in settings of multiple disasters, one study found profound difficulties in balancing home and work responsibilities among workers in the Florida Department of Health who had to respond to four hurricanes in 2004, and who were, in many cases, affected by the hurricanes personally

as well as professionally.⁶² Cherry and colleagues³¹ documented threats to cultural heritage, financial challenges, and lingering health concerns as major challenges faced by fishing communities in the Gulf Coast of the USA who were affected by Hurricane Katrina and the Deepwater Horizon oil spill. Two studies after the 2010 and 2011 Christchurch earthquakes in New Zealand found inequalities in trajectories of wellbeing and quality of life in the years following the earthquakes by income, ethnicity, and disability and physical health status.^{118,121} Conceptualisations of resilience in multiple disaster contexts were also critiqued, with one study finding that people in poor neighbourhoods of Rio de Janeiro, Brazil, faced constantly recurring disasters and used resilience strategies as a necessity.⁸²

Physical health

16 articles focused on physical health after multiple disasters.^{75,76,79,80,122–133} One study, which looked at 500 communities across the USA, found that those who had experienced recurring disasters had increased incidences of asthma, high blood pressure, and self-reported poor mental health and poor physical health. Moreover, the incidence of all such outcomes increased with each additional year in which a community experienced a disaster.¹²⁸ After Hurricane Katrina and the Deepwater Horizon oil spill in the Gulf Coast of the USA, one study (focused primarily on mental health) found that people exposed to both of these disasters had more physical health symptoms than did populations exposed to only one of the disasters,⁴¹ suggesting a cumulative effect. These studies highlight that exposure to multiple disasters can be associated with poorer self-rated health or increased physical health symptoms than exposure to one disaster.

Conversely, not all studies suggested a cumulative effect of multiple disaster exposures on physical health. One article on maternal and child health found that exposure to Hurricane Charley (2004) during pregnancy or shortly before conception was associated with increased risk of extremely preterm delivery; however, exposure to additional hurricanes did not seem to increase this risk further.⁸⁰

There were also indications of a connection between mental health and physical health outcomes in settings affected by multiple disasters. One study in the Gulf Coast of the USA suggested that losses as a result of Hurricane Katrina were associated with subsequent distress related to the Deepwater Horizon oil spill, which in turn was associated with physical health symptoms—suggesting that mental health effects from disasters can be one pathway to physical health effects.²⁹ Hayashi and colleagues¹²⁷ similarly found that post-traumatic stress disorder and insomnia after the 3.11 triple disaster in Japan was associated with increased fracture risk among older adults. Several studies in this same context also found a substantial increase in diabetes,¹²⁹ bodyweight,

body-mass index, waist circumference,^{131–133} and polycythemia¹³⁰ among populations exposed to the 3.11 disasters, with studies finding that those forced to evacuate were at greater risk of these outcomes than were non-evacuees.^{129–131}

Other studies found an effect of emotional repression on immune parameters in populations affected by multiple disasters,¹²² potential effects of multiple disaster exposures on child growth,¹²⁶ and patterns of waterborne and foodborne diseases after meteorological disasters.⁷⁹ Four articles focused on mortality after multiple disasters, including issues with death recording,^{76,125} and physical and social determinants of mortality.^{75,124}

Indirect implications for public health

Effects on health-care facilities

Four articles focused on health-care facilities in settings of multiple disasters.^{134–137} Three studies found staff shortages in the aftermath of the 3.11 triple disaster in Japan,¹³⁵ which persisted for up to 18 months after the disaster and affected local health-care facilities.^{136,137} One study looked at Hurricane Stan (2005) and a subsequent landslide in Guatemala and documented the immediate effects on one hospital, finding major structural damage but also a rapid recovery driven by a common vision shared by workers.¹³⁴ Across all identified cases, the affected hospitals continued functioning despite major logistical difficulties. Further research on indirect effects on patient care or on the health and wellbeing of hospital staff in multidisaster settings is warranted.

Risk perception and evacuation

Eight studies focused on public perceptions of risk and related behaviours in settings of recurring disasters, with mixed findings.^{43,52,59,60,65,78,138,139} Smith and McCarty⁶⁰ found that, during the four hurricanes in Florida, USA in 2004, hurricane strength was the primary predictor of evacuation behaviours during each hurricane; however, increases in the numbers of hurricanes experienced had no effect on the likelihood of evacuating. Similarly, one study of 19 large earthquakes in Sichuan province (China) found that the severity of past disaster experiences was strongly correlated with perceptions of disaster risk, but the number of past disaster experiences was not.¹³⁸ Wang and colleagues⁵⁹ looked at public complacency (defined as the public believing that the threat would not happen and ignoring it, or not preparing for it, even if the threat appeared imminent) during the 2004 hurricanes in Florida, and found that public complacency peaked after three hurricanes. Other studies across different settings have similarly suggested a need for further work to improve communication and knowledge exchange between residents and government actors in settings affected by recurring disasters,¹³⁹ with one study underscoring that multiple disasters could provide a window of opportunity for agencies to engage

citizens in preparedness.⁶⁵ Other studies have identified additional factors that might influence risk perception, evacuation decisions, or both in settings of recurring disasters, including gender,⁴³ the extent of losses in previous disasters,⁷⁸ and persuasion by family and friends.⁵²

There is a need for further research on how experiencing multiple disasters can influence risk perception and public responses to risk, and the indirect implications there might be for public health as a result (ie, from non-evacuation or delayed evacuation).

Household and community responses

Five articles focused on strategies for coping with multiple disasters at the household and community level.^{81,140–143} Bacon and colleagues¹⁴⁰ reviewed cumulative disasters in Nicaragua (coffee leaf rust from 2011 to present, drought in 2009, and Hurricane Mitch in 1998) and found a correlation between the coping responses that households used in past events and their continued use in subsequent disasters. Conversely, one study in Nebraska, USA documented various coping mechanisms for handling recurring severe drought in 2002–04 and 2012–14, and found that previous experience with the earlier drought resulted in different actions, including new water-conservation and land-use practices, in the later drought, with support from the government.¹⁴¹

Two studies examined the role of traditional knowledge systems of recurring disasters. Ngwese and colleagues⁸¹ studied communities affected by recurrent flooding and droughts in Ghana, and found that communities used traditional knowledge systems to prepare for disasters, while often viewing these practices as having low efficacy. In a study of climate-related hazards in Cambodia, Pauli and colleagues¹⁴² found that combining traditional knowledge and biophysical data could lead to a better understanding of so-called pressure points, at which the effects of recurring flooding become most severe, and the authors advocate for the co-production of knowledge between scientists and local communities.

Government responses

11 articles focused on government responses, including tensions in balancing national disaster management and local governance in multiple disaster settings,^{144,145} disruptions in communications to citizens caused by additional disasters occurring,¹⁴⁶ and organisational learning in government responses to multiple disasters.^{61,67,73,74,144–150} Kapucu and colleagues⁶¹ found no evidence for improvement in emergency management responses to each of the four hurricanes that hit Florida in 2004. Similarly, one study reviewed government responses to disasters that occurred over the course of two decades in the USA,¹⁴⁷ and another reviewed disasters that occurred between 1996 and 2005 in the Netherlands;¹⁴⁸ both studies found that the same problems were often

repeated in government responses to multiple disasters without improvement. Nohrstedt and colleagues¹⁴⁹ found that the frequency and severity of disasters experienced in 85 countries were not associated with improved disaster risk reduction policies in those countries, even after controlling for income levels, types of disaster and starting policies.

There is some evidence of government learning in different contexts. For example, Brody and colleagues⁷⁴ looked at floods in Florida from 1999 to 2005 and found evidence for policy learning over time in local government. One study of emergency response in China found that government-organised response and rescue operations improved after the Wenchuan earthquake of 2008 and were more efficient and effective during the Lushan earthquake of 2013.¹⁵⁰ In another study, Corbacioglu and Kapucu⁷³ found evidence for organisational learning, but only after multiple disasters that culminated in one of devastating scale. Little organisational learning was seen in Turkish disaster management after the Erzincan, Dinar, and Ceyhan earthquakes between 1992 and 1998; however, the devastating earthquake in Marmara in 1999 led to changes in disaster management in Turkey.

There is a need for further research on the public health implications of government responses and governmental learning versus non-learning in multiple disaster settings (and related policy changes or non-changes), as an upstream structural determinant of health.

Humanitarian and non-governmental organisation responses

One study assessed the occurrence and effects of disasters in the southern Africa region between 2000 and 2012, with a focus on humanitarian responses, and found that smaller, subnational disasters were reoccurring and compounding large-scale disaster events.¹⁵¹ However, this study found that large datasets often mask the effects of local and small-scale disasters, leading to bias in humanitarian disaster-relief responses, which focus on larger events. On a more local level, one study after the Nepal earthquakes in 2015 found that the operational reliance of non-governmental organisations on social capital to distribute support after a disaster contributed to inequities in access to resources.¹⁵²

Recovery processes

26 articles focused on elements of recovery from multiple disasters, including economic recovery,^{153,154} government and political factors in the recovery stage,^{53,66,155–160} community capitals,²⁴ schools as central hubs for recovery,¹⁶¹ disaster recovery committees,¹⁶² inequalities in recovery,^{163–167} and reconstruction experiences.^{150,168–170} This group also included articles on programmes undertaken in a recovery setting in low-income and middle-income countries, including a food security and

relief programme,¹⁷¹ a microcredit programme,¹⁷² a recovery aid programme,⁶⁹ and a global water, sanitation, and hygiene (WASH) programme.⁷⁰

Some studies looked at individual or household recovery experiences (eg, of reconstructing housing, or settling insurance claims);^{158,160,166,167,169,173} however, most focused on recovery at the community level^{24,69,70,154,172} or the country level.^{153,171} This focus was in contrast to some of the included mental health studies, which conceptualised individual-level recovery as the absence of mental health conditions or return to pre-disaster psychosocial or cognitive functioning.^{28,48,83}

Few of the 26 articles identified provided a definition of recovery, and those that did gave different definitions.^{160,163,166,167,169} The majority (23; 88%) of articles discussed recovery as a generalised concept, rather than recovery from multiple disasters. We identified only three articles that directly focused on the complexities of recovery from multiple disasters. Sargeant and colleagues¹⁶⁹ looked at the aftermaths of Typhoon Haiyan (2013) and Typhoon Haima (2016) in the Philippines and the Nepal earthquakes (April and May, 2015), and found that individual recovery was constrained by the continued need to respond to new cases of flooding, landslides, and monsoons. Ray-Bennett¹⁷² suggested that multiple disasters can produce complex crises that make recovery tenuous, and Himes-Cornell and colleagues²⁴ emphasised the need for further research into what happens to communities that experience a disaster while they are still recovering from a previous one.

Challenges to researching multiple disasters

Conceptual and methodological challenges were identified in the study of multiple disasters. Many studies noted issues in defining and measuring multiple exposures.^{28,41,85} Among quantitative studies on health outcomes (appendix p 18), there was a wide range of ways in which disaster exposure was defined and measured, and in some cases exposure was not measured directly. There was also a wide range of time periods covered between different disasters. For example, there were only 30 min between the 2010 Biobío earthquake and tsunami in Chile,^{87,88} but 11 years between the 9/11 terrorist attacks and Hurricane Sandy in New York City.¹⁰⁶ However, we could not identify any clear evidence for differences in the effects of multiple disasters depending on the timescale between exposures or on hazard type (ie, differences in multiple exposures to the same hazard type versus different hazard types), representing a need for further research. Some studies noted that they were affected by methodological constraints that are common across disaster research, including the limitations of naturalistic study designs and the inability to draw causal conclusions,^{26,28,29,32,55} absence of control groups,¹¹⁰ and difficulties in tracking and including disaster-affected individuals who relocated out of study areas.^{56,84}

Panel: Recommendations for supporting public health in multiple disaster settings**Mental health**

- Provision of mental health support services to populations affected by cumulative trauma such as multiple disasters.^{25,31,35,84,90,96,112,127}
- In mental health support interventions, screen for previous disaster exposures and other past traumas to identify populations at risk.^{37,41,87,98,102,106}
- In counselling protocols, account for history of post-traumatic stress disorder symptoms from past disasters.⁹⁴
- Whereas post-traumatic stress disorder and depression are commonly considered in public health screenings after a disaster, alcohol misuse, panic disorder, obsessive compulsive disorder and suicide risk are also relevant to screen for.^{97,98}
- Mental health services should be widely offered in communities affected by multiple disasters, rather than waiting for people to seek out support.³⁵
- Explore support options for children, young people, and families.^{28,87,113}

Wellbeing and resilience

- Psychosocial support programmes after multiple disasters.^{40,45,63,83,105,115}

Physical health

- Clinicians should be aware that experiencing traumatic events during multiple disasters can affect physical health,^{25,123,129-131,133} and should screen for exposure to past disasters.⁸⁹

Government responses

- Identify ways to improve links between governments and affected communities to enable more effective communication.^{59,67,68}

- Improve opportunities for local government officials to connect with decision makers in central government,¹⁵⁷ and strengthen subnational governance and integration of non-governmental organisations to improve responses to consecutive disasters.¹⁴⁴
- Develop new public policy strategies to support families affected by multiple disasters.¹²⁶

Risk perception and evacuation

- Strengthen community groups and support community leaders to increase localised communication about risks of multiple disasters.¹³⁸
- Create spaces in which local residents of disaster-affected places and governments can exchange information and experiences.¹³⁹

Recovery

- Consider the historical nature of trauma in an area and recollections of past disasters when examining effects of present disasters and working on recovery.⁹²
- Develop inclusive recovery frameworks, committees, and support programmes that recognise the needs of diverse communities.^{118,162,165,166,169}
- Develop policy and interventions to support people in preventing, preparing for, and recovering from ongoing or recurring disasters.¹⁶⁴ Ensure that any recovery interventions do not overlook crucial social, cultural, political, and environmental factors that can influence the recovery process.^{159,163,167}

It was notable that some articles (16; 11%) focused on a single disaster within a multi-disaster setting.^{31,32,36,86,90,112,113,116,117,124,135,137,154-157} There were also numerous quantitative studies in which the entire study population was affected by multiple disasters, without comparison to populations affected by no disasters or only one disaster (appendix p 18). We identified only one article that engaged with theoretical literature on compound or cascading disasters.¹⁵¹

Discussion

Our Review suggests that multiple disasters can have direct and indirect effects on physical health, mental health, and wellbeing, with evidence of cumulative effects. Moreover, multiple disasters can affect health-care facilities, population risk perception and evacuation decisions, household and community responses, government responses, humanitarian and non-governmental organisation responses, and recovery processes, in ways that go beyond what is seen from single disasters.

We could not identify consistent individual-level risk factors for adverse outcomes following multiple disasters,

with mixed results by age and gender. However, we found an emerging body of literature on the inequitable effects of multiple disaster exposures on physical health, mental health, and recovery processes at the community level. Hahn and colleagues¹²⁸ found that communities in the USA that had medium or high ratings on the Centers for Disease Control and Prevention Social Vulnerability Index (built from data on poverty levels, employment, educational attainment, and more) had the highest incidences of self-reported poor mental health, poor physical health, asthma, and high blood pressure after exposure to multiple disasters. Morgan and colleagues¹²¹ found uneven trajectories of wellbeing and quality-of-life scores in the aftermath of the 2010 and 2011 Christchurch earthquakes in New Zealand. Those who had low income, were Māori, or who lived with a physical health condition or disability were more likely to experience lower quality of life and wellbeing in the long term. A group of studies following the 2015 Nepal earthquakes emphasised inequalities in long-term recovery trajectories,^{163,166,167} finding that marginalised groups were more likely to face long-term displacement¹⁶⁴ and to be excluded from

Search strategy and selection criteria

The search strategy was informed by preliminary searches, and aims to account for different terms that are used to discuss multiple disaster scenarios. We searched Scopus, Web of Science, and PubMed from database inception to August 2, 2021, using the following terms: "cascading disaster*" OR "overlapping disaster*" OR "multi* disaster*" OR "compound* disaster*" OR "intersect* disaster*" OR "cumulative disaster*" OR "simultaneous disaster*" OR "concurrent disaster*" OR "consecutive disaster*" OR "repeat* disaster*" OR "recur* disaster*" OR "reoccur* disaster*" OR (multi* hazard*) AND (disaster* OR crisis OR crises OR emergenc*) AND recovery. This search resulted in 529 hits from Scopus, 931 from Web of Science, and 332 from PubMed. After 367 duplicates were removed, 1425 articles were screened.

We included peer-reviewed empirical academic articles published in English. Inclusion criteria were that articles focus on individuals or communities exposed to multiple disasters, and include discussion of the health, wellbeing, or social effects of these disasters; post-disaster activities; or economic, cultural, legal, or political effects that could influence health or wellbeing. To identify exposure to multiple disasters, we screened articles and included them for full-text screening if they either named more than one disaster (eg, the Great East Japan Earthquake and Fukushima Daiichi nuclear power plant disaster) or described scenarios in which more than one disaster occurs (eg, reference to recurring disasters), and indicated a defined population or place that experienced these disasters. Because of our focus on peer-reviewed empirical evidence, we excluded conference abstracts, theses, books, and theoretical or conceptual or commentary papers. We also excluded papers with a primary focus on infrastructure, technology, or risk modelling (ie, architecture, geospatial risk characteristics, or remote sensors).

Of the 1425 articles, 1116 were excluded during initial title and abstract screening because they did not describe a case of multiple disasters, leaving 309 articles for full-text screening. After this screening, 228 articles were excluded (figure 1) and 81 were included. The reference lists of all 81 included articles (apart from that of one systematic review) were then examined, and a further 69 articles that met the inclusion criteria were identified after full-text screening. With these, we included a total of 150 articles in the Review.

community-led reconstruction initiatives.¹⁶⁵ Still further research, policy, and recovery services will need to address inequities when advancing efforts to prevent, prepare for, respond to, and recover from multiple disasters.

Given the gaps we have identified, several recommendations can be made for further research. There is a need for further studies to examine differences between the effects of recurring disasters (of the same hazard type), and cascading disasters and consecutive disasters

with different hazard types. Equally, there is a need for further research to investigate whether effects might differ depending on the timing between disaster exposures. There is also a further need for research on the psychological effects of repeat disaster exposure,^{57,101} how previous disaster exposure affects the experience of any subsequent disasters,²⁵ the effect of multiple disasters on preparedness and recovery,⁴³ and the physical health effects of multiple disasters.⁴¹ There is also a clear need to better understand the long-term effects of multiple disaster exposures.³³ In addition, although this Review has looked back at previous cases of multiple disaster exposures in individuals and communities, there is also a future-facing body of work on risk assessments (eg, in urban planning) and the all-hazards approach to disaster preparedness that will be relevant for reducing the public health risks of multiple disaster exposures.¹⁷⁴ Linking studies on the documented effects of past disasters with future-facing studies on modelling and reducing multi-disaster risks will be important in future work.

Recommendations for practice

In addition to the research recommendations that we have discussed, there are also several recommendations for practice that can be taken from this Review. There is scarce evidence to date on how to best support the health and wellbeing of people and communities after multiple disaster exposures. There is a pressing need for work on intervention programmes that are tailored to multi-disaster scenarios, given the ways in which the effects of these scenarios might differ from those of single disasters and the potential need for overlapping preparedness, response, and recovery activities in relation to different hazards. The panel summarises a range of recommendations for practice made in the identified articles, covering mental health, wellbeing and resilience, physical health, government responses, and recovery, and we suggest a need for integrated action across these categories. Many of these recommendations were similar to those made in the context of single disasters, for example providing widespread mental health support services. However, some recommendations were specific to multiple disasters, such as screening for past disaster exposure in interventions responding to new disasters.

Limitations

First, a general limitation of scoping reviews is that they do not systematically appraise the quality of evidence.²¹ This approach is suitable for the current topic, given the emerging nature of knowledge on multiple disaster exposures, and the fact that public health implications have been studied by diverse disciplines and methods. The current findings could inform a further systematic review or meta-analysis (eg, focused on quantitative studies of mental health outcomes). Second, only English-language articles were included. Third, we categorised articles on the basis of the primary focus we identified

within them; however, there were cases in which the boundaries between categories (eg, between mental health and wellbeing) overlap. Fourth, because we were unable to include all potential combinations of hazard types in the search terms, this Review identified only cases that were described as multiple disasters; however, there are likely to be more cases than those actively described as such. For example, since completion of this Review, we have identified a relevant article on multiple disaster exposures that refers to people with multiple disaster exposures as exposure outliers.¹⁷⁵ Fifth, we recognise that the definition of where disasters begin and end can be unclear. There is increasing emphasis from some researchers that disasters should be thought of as processes, rather than events;¹⁷⁶ however, this framing was not present in most articles that we reviewed. Sixth, this Review focused on direct and indirect public health implications and the recovery stage of the disaster cycle, and did not include specified search terms on preparedness or resilience. Finally, we did not include grey literature in this review; however, the existence of increasing amounts of grey literature on multiple disasters should be noted.

This scoping review outlined existing research on the public health effects of multiple disasters and recovery from these disasters. We underscore the relevance of public health implications of multiple disaster exposures. Given the projected increases in extreme weather events owing to climate change, there is a pressing need to become better equipped to address public health in settings of multiple disasters.

Contributors

CL and LG conceived and designed the study. CL acquired and analysed the data. CL, LG, KB, LR, and PQ contributed to the interpretation of data. CL drafted the manuscript, and all authors revised it critically for important intellectual content. All authors give final approval to the version to be published, and agree to be accountable for all aspects of the work.

Declaration of interests

We declare no competing interests.

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