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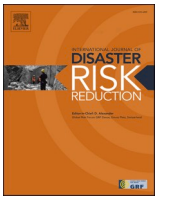

The 2023 floods in the Emilia-Romagna Region, Italy: A retrospective qualitative investigation into response strategies and criticalities

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ABSTRACT

In May 2023, the Emilia-Romagna Region experienced two unprecedented rainfall episodes, leading to severe flooding and landslides especially in its southernmost part, the Romagna area. This study aimed to assess the health response to the May 2023 floods in this area, by identifying the main actions undertaken in response to the floods and by highlighting criticalities and lessons learned. To achieve this objective, a retrospective qualitative case study design was chosen, and semi-structured interviews were carried out to gather in-depth information on the experiences and perspectives of 25 key informants (authorities and public administration, health management, public health, primary care, social services, hospital and emergency care system, communication, and third sector) involved in the response. The findings highlight the strain on the local health system, including service and infrastructure disruptions. The response strategies have been analysed and clustered in phases (alert and activation, coordination, communication, identification of vulnerable individuals, evacuations management, surge capacity, health service

Abbreviations: Arpae, Agenzia Prevenzione Ambiente Energia Emilia-Romagna; Auser, Italian Association for Active Ageing; CCS, Centro Coordinamento dei Soccorsi; COC, Centro Operativo Comunale; COREQ, Consolidated Criteria for Reporting Qualitative Research; ED, Emergency Department; EEA, European Economic Area; EMDR, Eye Movement Desensitization and Reprocessing; EU, European Union; EWE, Extreme Weather Event; GP, General Practitioner; H-EDRM, Health Emergency and Disaster Risk Management; IPCC, Intergovernmental Panel on Climate Change; ISO, International Organization for Standardization; ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale; LHA, Local Health Authority; NGO, Non-Governmental Organisation; NUCOT, Hospital-Territory Continuity Unit; PAHO, Pan American Health Organization; PASS, Social and Primary Care Assistance Point; PPE, Personal Protective Equipment; RLHA, Romagna Local Health Authority; SIPEM, Italian Society of Emergency Psychology; Unitalsi, National Italian Union for the Transport of the Sick to Lourdes and International Sanctuaries; WHO, World Health Organization; WMO, World Meteorological Organisation.

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delivery, logistics, and the role of volunteers), offering a comprehensive overview of local disaster response strategies. Recommendations include enhancing interoperability of health information systems for disaster management, improving the coordination of evacuations for at-risk populations, and strengthening spontaneous volunteers' management. This study highlights the importance of collaborations between local health authorities and academia for ongoing evaluations to enhance disaster response and resilience.

1. Introduction

Fluvial floods occur when there are intense rains over an extended period of time, causing the water levels of rivers to rise and overflow into the surrounding areas [1]. Climate change is increasing the frequency and intensity of extreme rainfall events, thereby raising the risk of flooding [2]. Additionally, due to uncontrolled urbanisation, a growing number of people are living in river basins [3], which could result in more and more people being affected by floods in the future.

Between 1980 and 2022, 5.582 lives were lost due to floods in 32 countries within the European Economic Area (EEA) [4]. Although the number of deaths has decreased over time due to more attention being paid to disaster management practices [5], the recent flood that hit Western and Central Europe in 2021 caused 212 deaths, making it the deadliest flood in Europe in the last 50 years [4].

It is estimated that floods in Europe affected 1,6 million people and accounted for 81% of the annual economic losses due to climate-related causes in 2023 [6]. The first significant flooding event occurred in May 2023 when Storm Minerva caused heavy rains leading to floods in the Italian regions of Emilia-Romagna and Marche. Subsequently, Slovenia was hit by heavy and persistent rains in the first half of August. Also in early August, Storm Hans brought heavy rains and winds affecting Northern Europe, including Norway, Sweden, Denmark, Finland, Estonia, Latvia, and Lithuania. Finally, in September, floods struck Greece, Bulgaria, and Turkey following intense rains caused by Storm Daniel [6].

At the European level, flood risk management is regulated by the European Union (EU) Directive 2007/60/EC [7], which acknowledges the impact of human-induced climate change on the increasing severity of floods. The directive aims to mitigate the negative impact of floods through tailored solutions and regional cooperation. Particularly, flood management follows a multi-level structure, whereby each State is required to develop flood risk management plans for each river basin and designate competent authorities responsible for implementing the directive at the national level. Besides flood management plans, States also implement Civil Protection plans to respond to extreme weather events (EWEs), frequently collaborating with regional and local authorities. Additionally, the European Commission emphasises the urgency of addressing these issues through the priorities set by the European Green Deal [8] and the 2021 EU Strategy on Adaptation to Climate Change [9].

In Italy, the European Directive 2007/60/EC was implemented through the Legislative Decree 49/2010 [10], and the Flood Risk Management Plan is incorporated into river basin-level planning as a tool for managing flood risk. The management of the health impacts from the floods is integrated into a broader disaster management framework overseen by the National Civil Protection Service, which established that the initial emergency response must be provided at the local level [11].

The Italian Civil Protection system mandates that the coordination and management of disasters, including floods, are conducted through local-level decision-making bodies comprising representatives from various operational functions, including health system representatives [12]n.d. For instance, at the municipal level, the Municipal Coordination Centre (*Centro Operativo Comunale*, COC) is established and led by the mayor, whereas, at the provincial level, the Rescue Coordination Center (*Centro Coordinamento dei Soccorsi*, CCS) is set up and led by the prefect.

Other operational structures that are part of the national Civil Protection mechanism and provide support in emergencies or disasters are the National Fire Brigade Corps, the Armed Forces (Italian Army, Navy, Air Force), State Police Forces (State Police, Carabinieri, Guardia di Finanza, Penitentiary Police), the State Forestry Corps, National Research Centres, Voluntary Organisations, the National Alpine Rescue Corps, as well as bodies responsible for public health and health emergency management such as the Red Cross and the National Health Service [13].

Given the complexity of the national disaster management system and the involvement of various actors from different institutions, examining the actions taken during the health response to EWEs is challenging, as is identifying response phase shortcomings. Nevertheless, the importance of conducting After Action Reviews and evaluations of post-disaster responses [14] is widely recognized. This process constitutes a crucial phase bridging the recovery and preparedness stages in the disaster risk management cycle [15].

Although the floods that struck the Emilia-Romagna Region in May 2023 were devastating and garnered national and international recognition, to date there is a lack of scientific evidence regarding the actions undertaken in the response, and there have been no systematic studies examining the identified challenges.

1.1. The floods in the Emilia-Romagna Region in may 2023

The heavy rains during the first half of May 2023 were the most intense ever recorded, and it is estimated that such an event may occur only once every 200 years. This implies that the likelihood of a similar event happening in any given year is about 0,5% [16]. In particular, the flood event was characterised by two episodes of intense rainfall: the first, in early May, of lesser magnitude, and the second, in mid-May, which was more geographically extensive and intense, exacerbating the situation already compromised by the

first event. The impact of the floods was concentrated in the Romagna area, namely the southeastern part of the region.

On April 20, 2023, the Civil Protection issued an orange alert – representing a moderate level of risk – for severe thunderstorms in Emilia-Romagna. On April 24 and 25, thunderstorms and hailstorms hit some provinces within and outside the Romagna area, namely Ferrara, Parma, Reggio-Emilia, and Rimini. The heaviest rains began on May 2, triggering a red alert after 12 h. Within 48 h, 200 mm of rain fell in the provinces of Bologna, Ravenna, and Forlì-Cesena, primarily affecting the Romagna area, and causing rivers to overflow and flooding in various locations. By May 4, there were reports of 23 rivers overflowing, 15 levee breaches, over 140 landslides, and severe infrastructural damage. Additional rains on May 9 and 10 worsened the situation. On May 16 and 17, precipitation reached record levels, with 300 mm of rain in Forlì and up to 200 mm in Ravenna and Bologna. By May 18, 8.000 volunteer person-days provided support to manage the disaster, and a state of emergency was declared for 12 months. Before May 25, 23 rivers had overflowed and 13 had reached alarming levels, causing 50 floods in 42 municipalities and over 370 landslides, resulting in the closure of more than 700 roads. As of May 20, there were 36.600 evacuees and 17 deaths, primarily among the elderly [17] (Fig. 1).

1.2. Study objective

The objective of this study is to evaluate the actions undertaken in the health response to the floods that struck the Emilia-Romagna Region in May 2023, particularly focusing on the Romagna area, aiming to identify best practices and areas for improvement. In particular, this qualitative investigation was guided by the following empirical research question: “What actions were undertaken in the health response to the floods that struck the Romagna area in May 2023 and what areas for improvement can be identified from this experience?*”,* which was further broken down into three secondary sub-questions: i) “What were the main impacts of the floods on the health system?", ii) "What actions were implemented in the health response to the floods?" and iii) “What challenges and recommendations for improvement were identified by respondents?".

This study provides: i) a comprehensive understanding of the flood response; ii) an analysis of challenges and best practices during the flood response; iii) evidence-based recommendations to strengthen or enhance responses to similar events that may occur in the future.

2. Methods

We used semi-structured interviews to explore the perspectives of multiple key informants on the local health response to the 2023 floods in the Romagna area, in the Emilia-Romagna Region, Italy.

This study was conducted in the context of a collaboration between CRIMEDIM, Center for Research and Training in Disaster Medicine, Humanitarian Aid and Global Health, and the Romagna Local Health Authority (RLHA). The Italian National Health System operates extensively throughout the Italian territory by decentralising healthcare services. This is achieved through regional health systems within which various local health authorities (LHA) operate. The RLHA is one of the largest and most relevant social and health organisations in Italy, with a production value of approximately 2,5 billion euros and over 16.000 employees. It is responsible for the health protection of about 1.125.000 residents in the 75 municipalities of the provinces of Ravenna, Forlì-Cesena, and Rimini [19].

The methods have been reported in accordance with the Consolidated Criteria for Reporting Qualitative Research (COREQ) [20].

2.1. Study design

In this study, we adopted a descriptive case study design [21] to qualitatively investigate key stakeholders’ experiences and perspectives regarding the flood response in the Romagna area. A mapping process was undertaken to pinpoint the main agencies typically engaged in the health response to EWEs in Italy. Purposive sampling was used to select participants who could provide rich, accurate and diversified data in relation to the research objective. To be eligible to participate in the study respondents needed to have been involved in the response to the floods and to have provided their informed consent.

Key informants were contacted via e-mail. Information on the study objective, methodology and ethical considerations was attached to the email. Upon confirmation of participation, they were offered several time slots for the interview and chose the one fitting their schedules. Interviews were conducted face-to-face in the Romagna area at the location of their preference or online via Zoom [version 5.17.11 (31580)].

2.2. Data collection

A semi-structured interview guide (Supplementary File 1) made up of leading and probing questions was developed, keeping in mind the objective of the study and drawing on the WHO Health Emergency and Disaster Risk Management (H-EDRM) framework [22] and the WHO Guidance for After Action Review [14]. Specifically, the H-EDRM framework, developed by the WHO in 2019, served as the conceptual framework enabling the deconstruction of emergency response and disaster risk management into distinct thematic subcategories. It also facilitated the conceptualisation of the health system as a complex system which, in its broadest scope, encompasses the third sector agencies. Meanwhile, the Guidance for After Action Review informed the methodological approach for the qualitative assessment of the system’s response performance, focusing on identifying critical gaps and gathering recommendations to enhance preparedness for future flood events within the context of a cyclical approach.

The interview guide was divided into three sections: i) introduction and general information about the key informants’ role during the floods, ii) detailed overview of the actions taken in response to the floods, and iii) final considerations and conclusions. The same

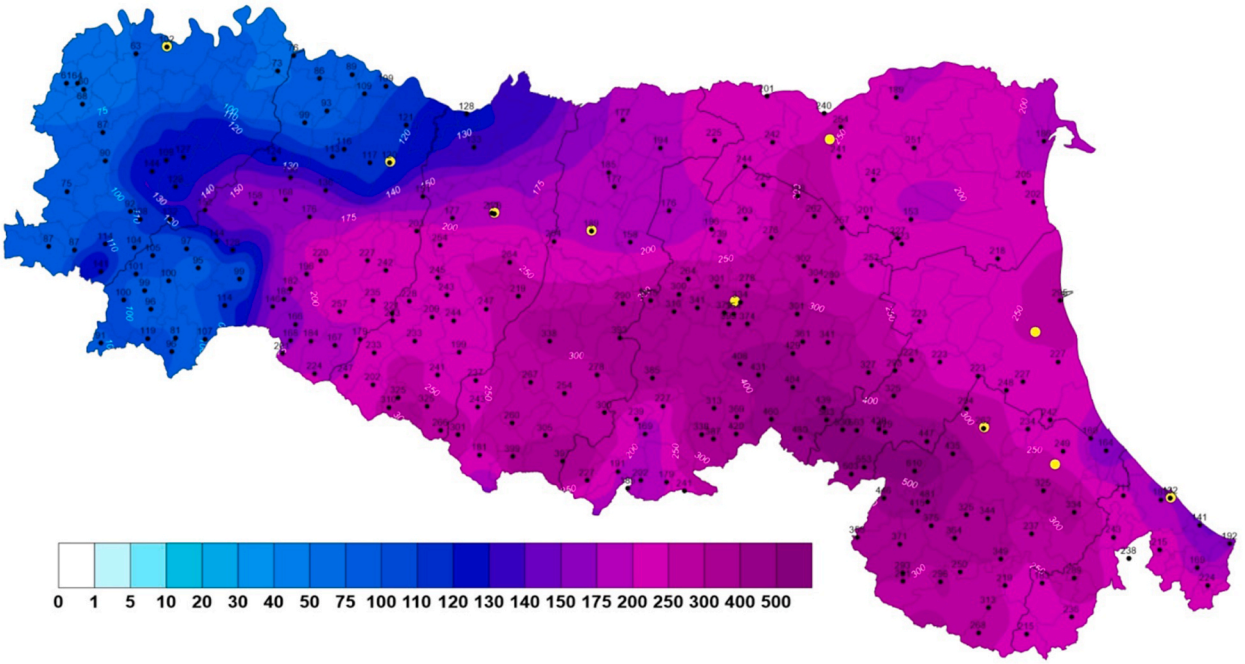

Fig. 1. Cumulative precipitation in the Emilia-Romagna Region over May, 1–17, 2023[21] [18].

interview guide was used to interview all key informants, with minor linguistic adaptations to address stakeholders from different sectors.

Interviews were conducted from the second week of October 2023 to the second week of December 2023 and lasted from one to two hours. After receiving consent from the respondents, interviews were audio recorded. Notes were taken during the interviews by interviewers who did not lead the conversation. Interviews were conducted in Italian and text segments reported in this article have been translated for publication purposes.

Table 1
Characteristics of the interviewees.

Main area	Role
Authorities and public administration	Municipal authority
	Environmental and territorial protection manager
	Councillor for social policies
	Councillor with responsibilities for civil protection, security, and transparency
	Member of Civil Protection Modular Functional Units ("colonne mobili")[a]
Health management	Health district director
	Health district director
	Health district director
	Health district director
Public health	Public Health Department director
Primary care	Community Psychology Services director
	Nursing and technical management director
	Health Centres and Community Hospitals manager
	Nursing homes manager
	Primary care department director
Social services	Coordinator, social worker
	Inter-area youth and social-educational programs director
	Welfare area director
Hospital and emergency care system	Emergency department director
	Head of emergency medicine department, emergency room
	Emergency room nurse
Communication	Head of press office
Third sector	Field operations director[a]
	Program coordinator[a]
	Physician, National Alpine Rescue Corps

[a] key informants coming from outside the Emilia-Romagna Region.

2.3. Data analysis and reporting

Interviews were transcribed verbatim by first converting audio files to text via the transcribe function of Microsoft Word and then manually checking for completeness and quality. A codebook was developed by relying on the study objective and theoretical underpinnings (Supplementary File 2). The codebook was used to deductively code the transcripts, and it was kept flexible to be adapted in case new codes emerged inductively from the text. The analysis was performed by three researchers (MV, CDP, GF) to ensure triangulation and validity.

Results are reported in the following section in written format; translated quotes have been added to the text to deepen comprehension of certain concepts and optimise understanding at specific instances.

2.4. Ethical considerations

The study was conducted according to the principles enunciated in the Declaration of Helsinki and it is exempt from the requirement to seek ethical approval. All participants were required to provide their informed consent to participate in the study. Sufficient details were provided at the beginning of the interview about the study's aim and process. The data collected was anonymised and access to the data was restricted to the co-authors of this paper only.

3. Results

A total of 25 key informants from different areas were interviewed: authorities and public administration (n = 5), health management (n = 4), public health (n = 1), primary care (n = 5), social services (n = 3), hospital and emergency care system (n = 3), communication (n = 1), and third sector (n = 3). Characteristics of interviewees are reported in Table 1.

The results are presented below divided into thematic areas. First, the impact of the floods on the health system is described. Then, a detailed description of the actions undertaken during the response is provided. Finally, the critical issues and recommendations outlined by the interviewees are reported. The mentioned affected municipalities in the study have been pinpointed in Fig. 2, alongside the Romagna area, as a reference for the reader.

3.1. Impact of the floods on the health system

Different components of the Romagna health system were impacted by the floods, particularly human resources, health service delivery, infrastructures and medical equipment.

3.2. Human resources

The impact of the floods on human resources has been twofold: on one hand, resident health professionals were directly affected by the floods; on the other hand, their workload increased to ensure continuity of services to the population. Some health professionals reported being unable to commute to work because the roads were damaged, they lost their vehicles due to the floods, or their homes were flooded, and their priority was to evacuate their families. In Lugo, slowdowns in the restoration of health services were partly due to reduced staffing, which in turn was caused by limited road accessibility. In Faenza, nursing staff were offered the opportunity to stay overnight in the hospital after their shift to ensure service continuity. Volunteers from other regions, who came to support the affected areas, reported to have experienced emotional impact.

3.3. Health service delivery

The interviewees shed light on which health services were impacted by the floods. Elective and outpatient activities were suspended for six days and rescheduled within the following 30 days. In Faenza, despite most hospitals remaining operational, some non-essential services such as blood tests and specialist and diagnostic outpatient activities were interrupted for seven to ten days. Elective surgery procedures were suspended in several facilities for two to seven days. Some centres were re-purposed to respond to the emergency. For example, after suspending non-urgent activities, Ravenna's health district arranged for the reception of vulnerable individuals in facilities where health services were temporarily suspended. In Lugo, located in the Ravenna province, the cardiology outpatient clinic hosted the Emergency Department (ED) services, since the usual facility, located on the ground floor, was at risk of being flooded. Areas dedicated to day hospital services were converted to accommodate displaced individuals with high-level care needs. In two other cities in the Ravenna province, Faenza and Solarolo, groups of General Practitioners (GPs) moved their clinics to evacuation centres.

[2] Source: report ARPAE L'Evento Meteo Idrologico e Idraulico del 16–18 Maggio 2023 (https://www.arpae.it/).

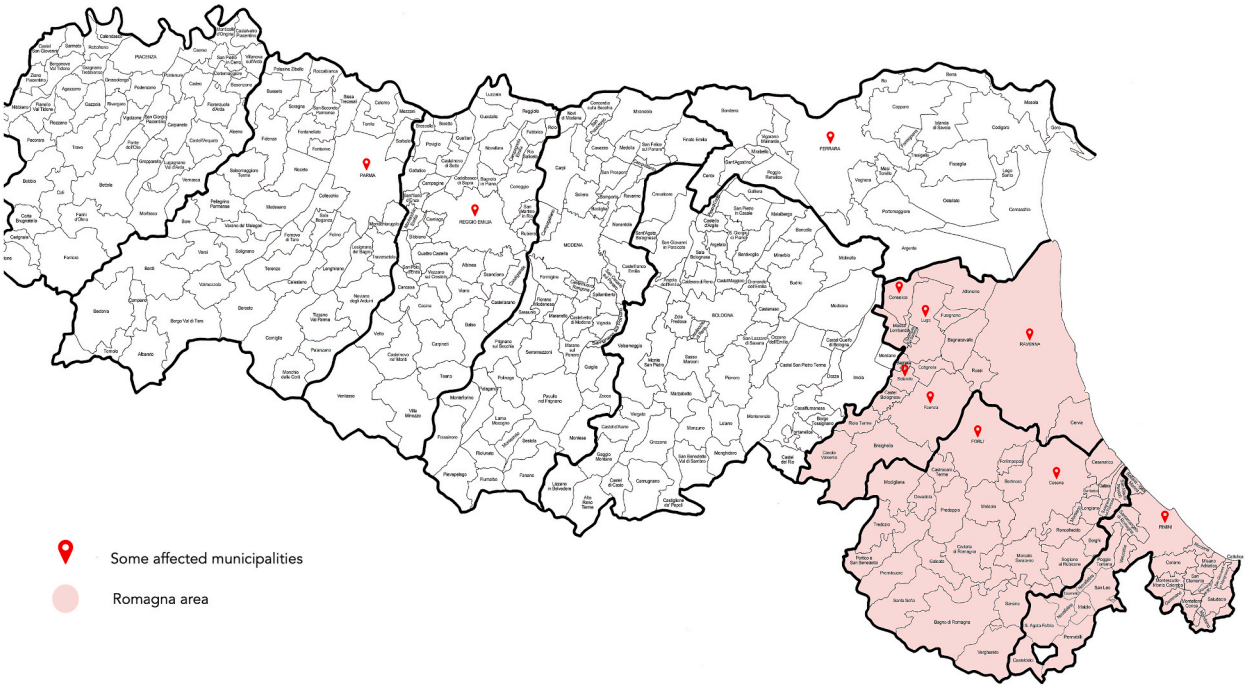

Fig. 2. The Romagna area and some affected municipalities that are mentioned in the text.

3.4. Infrastructure and medical equipment

Several infrastructures were severely impacted by the floods. Among the most affected facilities were daycare and nursing homes, outpatient clinics, group ambulatories, and a building hosting district health services in Lugo. Located in the city centre, the latter housed a series of crucial services on the ground floor, including the central booking office[3], home care services, archives, a dental clinic, a counselling centre, administrative offices, and the district headquarters. In Cesena, the roof of the neuroradiology department was damaged by the rains, with water leakage damaging two MRI machines and a CT scan. Additionally, the administrative centre in Cesena was impacted because all the technological equipment, including servers, air conditioning systems and control units were located in the basement. In Forlì, a private nursing home was damaged by the flood; the radiology area was submerged, causing damage to an MRI machine and a CT scan. One of the participants highlighted how this event also impacted the public healthcare system, as the accredited private facility provided services on behalf of the RLHA, and therefore it became necessary to plan for service recovery by purchasing services from other private facilities. In Faenza, numerous elderly daycare centres had to abruptly shut down due to the premises becoming inaccessible and some nursing homes were evacuated. A cluster of outpatient ambulatories had to move their offices to a reception centre due to the inaccessibility of the clinics. Damages also affected utilities (electricity, water) and telephone services. In some cases, such as in Conselice, the lack of telephone connection lasted up to a week.

4. Actions undertaken in response to the floods

The main actions undertaken by the different actors in response to the floods have been identified and categorised in different phases: alert and activation, coordination, communication, identification of vulnerable individuals, evacuation management, surge capacity, health service delivery, logistics, and the role of volunteers.

4.1. Alert and activation

At the end of April, the Civil Protection and the Weather Alert Centre issued the first yellow alerts for thunderstorms. A state of emergency was declared following the first flooding on May 2–3, which was extended to incorporate also the flooding on May 16–17.

For the second flooding, the intervention began as early as May 14. Municipal authorities in the at-risk districts and municipalities—Ravenna, Faenza, Lugo, Forlì-Cesena and Rimini—immediately provided instructions to the population, such as moving to higher floors and relocating cars to higher points in the city. Healthcare workers were also mobilised for the following 24 h. Social workers alerted all networks that could potentially assist in the disaster response.

[3] Centralised booking system used in the Italian healthcare system for scheduling medical appointments, tests, and services.

4.2. Coordination

The two flooding events differed in intensity and extent, requiring different coordination efforts. For the first flooding event (in early May), the activation of the Municipal Operations Center (COC) in the affected municipalities was sufficient to coordinate the response, whereas the May 16–17 flood required the activation of the emergency services operations centres, the Crisis Unit, the Rescue Coordination Center (CCS), and the COCs in all the affected municipalities. The latter served as the tool through which the Civil Protection coordinated the efforts of all the entities involved in the disaster response, including the National Alpine Rescue Corps, the Red Cross and the Civil Protection mobile units. The districts made arrangements with social and health facilities to prepare for potential evacuations. The role of pivotal figures, such as health district directors, bed managers, and operational centres such as the unified emergency services operations centre and the NUCOT (Hospital-Territory Continuity Unit) facilitated centralised information sharing and decision-making within the health system.

4.3. Communication

To reach citizens with weather alert notifications, the municipality of Faenza requested the population to download the Civil Protection App between the first and the second flooding event; mass social media was also used. Local police and street units used flyers, megaphones, and door-to-door communications to reach people with evacuation information. In some cases, it was necessary to draft a letter signed by GPs in collaboration with the mayor to convince sceptical citizens to evacuate. As for help requests, an inter-municipal number was activated.

Information about activated preventive health services was also shared. The RLHA designated the public health department director as the sole official communicator. These communications efforts encompassed the distribution of a flyer outlining emergency protocols including hazard awareness, recommended clothing and sanitation guidelines, the tetanus vaccination campaign, implemented with the support of the Red Cross, and telephone contact points and addresses of centres dedicated to psychological support.

The management of donations and volunteers also required structured communication channels. In Faenza, where an external third-sector organisation intervened in support of donation management, a joint press release was issued by the Municipality and the Non-Governmental Organisation (NGO) to clearly define the essential goods needed. To manage spontaneous volunteering, a digital platform was used (“Volontari SOS”) allowing volunteers to register from all over Italy and know in advance which city they could go to for support.

4.4. Identification of vulnerable individuals

In the days before May 16, a mapping process was implemented to identify vulnerable individuals affected by the flood, flood-prone structures requiring evacuation, and facilities capable of accommodating evacuees. Through databases, the districts were able to identify individuals with disabilities, the elderly, those on dialysis, ventilated individuals, and those under home care. Yet, a portion of unknown vulnerability - whether social, health-related or caused by non-self-sufficiency - emerged. Social workers facilitated the identification of such vulnerable individuals through phone calls; if the phone call revealed a condition of vulnerability, the person was transferred to reception facilities under the coordination of the bed manager.

The rule for assigning individuals to facilities was the result of an emergent process, not a predefined fragility algorithm. Specifically, "*those with disabilities, families with young children, the elderly, and individuals with mental health issues were immediately directed to protected facilities or departments identified in the previous days*" (Health management). Those without specific social/health needs were sent to reception centres before undergoing a secondary vulnerability assessment conducted by nurses, social workers, and doctors. This ensured a multidimensional assessment of needs and the relocation of individuals to more appropriate reception facilities.

4.5. Evacuations management

Preventive evacuations were carried out for the mid-May floods, following the Civil Protection orders defining red zones; these evacuations affected both residential homes and healthcare facilities. Reception centres were set up to accommodate evacuated individuals: Faenza "*had one of the city's sports centres equipped with 80-100 beds to accommodate people as early as May 15*" (Authority and Public Administration). Reception centres had also to accommodate caregivers of elderly or non-self-sufficient people, pets, mostly dogs and cats, and children, for whom babysitting services were activated to allow parents to go to work.

Other structures used for evacuations included: family centres, hotels, farmhouses, elderly care facilities, mental health service facilities, high-dependency rehabilitation communities, foster homes, housing communities, social centres, gyms, and hospitals. In particular, "*the hospital provided a high-performance facility for individuals who did not have acute issues, traditionally requiring hospitalisation, but who, due to chronic, multi-pathological conditions, were more challenging to manage in a reception centre*" (Hospital).

The transfer of individuals to designated reception facilities in the area was made possible through the collaboration of various entities: public administrations, social workers, healthcare services including emergency services, volunteers including the Red Cross, law enforcement, and the third sector. Primary care providers and bed managers played a key role in supporting evacuations, enabling swift transfers of individuals. They created daily transfer reports containing information about the transferred person, the person who authorised the transfer, the destination, and the admission and discharge dates.

Actions taken in the context of evacuations continued during the recovery phase. These involved closing the reception facilities and relocating evacuees. In this phase, it was difficult or sometimes impossible for people to return to their homes, which had been

rendered uninhabitable by the water: "*the entrance into the reception facilities was very rapid, the return home was more complex.* […] *It was a long process requiring huge collaboration with social services*" (Primary Care).

4.6. Surge capacity

The implementation of surge capacity began in the alert phase. Healthcare personnel were increased with a rotation of shifts to ensure 24/7 service activity. To accommodate evacuated individuals, the capacity of various facilities was either increased or repurposed. Spaces designated for outpatient surgical services housed the most medically fragile evacuees. Public healthcare facilities (nursing homes, day centres, etc.) and community structures (gyms, sports halls, schools and hotels) were also employed for evacuations.

During the response phase, the system intensified efforts to increase surge capacity, enhancing the response capability based on the population's growing needs. The surge capacity for personnel involved an increase in human resources, extended working hours, and task shifting to non-traditional roles and duties. Volunteers, NGOs, and associations such as the Red Cross, SIPEM (Italian Society of Emergency Psychology), and the Association for EMDR (Eye Movement Desensitization and Reprocessing) helped boost the available mental health workforce in response to the disaster.

The surge capacity also involved equipment and transportation. Local health service transport was supplemented by vehicles from the Red Cross, Air Force, Carabinieri, citizens, and private sector contracts. Water pumps arrived from the Civil Protection mobile units from other Italian regions and European pumping stations (Belgium, Slovakia and Slovenia). The Civil Protection provided containers that served as social and primary care assistance points (PASS).

4.7. Health service delivery

Healthcare needs primarily concerned social and assistance services. The flow of patients to the ED varied depending on the geographic area, the operational status of the hospital infrastructure, the need to accommodate evacuees from nearby facilities, and population mobility. For example, Faenza's ED saw a temporary spike in visits due to the closure of the nearby hospital in Lugo, which quickly subsided. Overall, no hospital plan for mass casualties was activated and, in general, ED visits included cases of hypothermia, minor trauma, gastroenteritis, and skin infections. Some interviewees indicated that many minor trauma cases consisted of volunteers' injuries operating in the affected areas. Social, health and assistance needs were managed by general practitioners, paediatricians, nurses, volunteers from various associations and social services. Reception centres had 24/7 staff to ensure continuous assistance.

In reception centres, outpatient areas staffed by nurses and doctors were established to ensure continuous care and primary health monitoring. Mobile units, such as vans or PASS, equipped with a doctor, nurse, computer, and essential medications, were used in the field to provide ongoing care. General practitioners and on-call doctors collaborated with pharmacies to streamline prescription processes and ensure home delivery of medications.

Psychological support was provided to both citizens and response operators. The initial intervention was implemented on May 19 by the psychology unit within the RLHA, which activated a dedicated phone line for psychological support. In the following days, the activities increased, bolstered by additional human resources. Interventions took place at listening points, town squares, and reception centres. In the latter, proximity psychology was ensured through simple dialogue with citizens: *"We tried to create a small room, a space. In the centre in Lugo, which was actually a gym, I put down some mats, and we created a room with a table and two chairs with a handmade sign saying 'psychological* support*' … and people came" (Primary Care).*

In the second week post-flooding, two key interventions were undertaken for public health: the dissemination of a handbook with risk information and the launch of a tetanus vaccination campaign for citizens and volunteers in contact with stagnant water. Hepatitis A vaccinations were also administered in Conselice, where water stagnated for an extended period. Mosquito proliferation in stagnant water areas prompted action, including the use of insecticides. Despite lacking a pre-established health surveillance system, the public health department swiftly mobilised to implement one, albeit nearly a month after the disaster.

During the recovery phase, healthcare services in affected areas restored interrupted activities, including blood tests, specialist consultations, diagnostic procedures, and scheduled surgeries. Data gathered by psychologists during the acute disaster phase formed the basis for organising summer activities for children and adolescents and for devising individual or group interventions in affected areas.

4.8. Logistics

Logistics measures focused on meal delivery, drug distribution, and donation management. Meal delivery involved two main areas: home delivery and the setup of dining points for displaced people or those who could move. For home delivery, packages were prepared to make people self-sufficient for 24 h.

As for drug distribution, in the Forlì-Cesena district, the public pharmacy association handled distributing medications both to shelters and homes for the first 4–5 days. A phone number connected citizens with a doctor, who prescribed the medication. The pharmacy, in collaboration with the Civil Protection, delivered the medication at home.

Donation management relied on assistance from the non-profit sector. In Faenza, the NGO EMERGENCY made a significant logistical effort to sort, store and distribute donations. EMERGENCY, in coordination with the local government, set up a large logistical hub to collect donated goods (both food and non-food items, such as cleaning products and items for clearing debris - shovels, water pumps, sponges, boots, gloves, pressure washers, etc.). A warehouse logistics management process was implemented to predict

needs in the coming days and share this information with potential donors.

4.9. Role of volunteers

Volunteers were a crucial resource in supporting all actions taken in response to the disaster. Coordination with other involved parties was ensured through the CCS and COC. During the first flood event, the volunteer effort was mostly at the local level. However, during the second flood event, thousands of volunteers from all over Italy were mobilised: "*They were there with people and equipment, playing an essential role. You can't keep 10,000 people on standby waiting for an event to happen; instead, volunteering activates thousands of people within hours*" (Primary Care). Organised volunteer efforts included operators from the Red Cross, Caritas, Civil Protection, Mountain Rescue Corps, Firefighters, Save the Children, EMERGENCY, Auser (Italian Association for Active Ageing), Unitalsi (National Italian Union for the Transport of the Sick to Lourdes and International Sanctuaries), and local volunteer associations.

5. Critical issues and recommendations

Interviewees identified a series of issues concerning the response to the May 2023 floods and subsequently provided recommendations to enhance future flood response efforts. The issues and recommendations are organised below according to the relevant phase of flood management.

5.1. Prevention and preparedness

As for plans and protocols, interviewees identified the absence of integrated and hazard-specific protocols, the lack of integration between medical emergency management protocols and protocols from the Civil Protection, and the lack of specific guidance for the primary care system as the most relevant criticalities.

When it comes to preparedness, interviewees highlighted opportunities for improvement regarding the funding of third-sector entities involved in the response. They expressed a desire for increased investments in enhancing the preparedness of health staff, including a greater focus on capacity building for risk communication. Additionally, they noted the potential for more simulations to better familiarise with existing plans and protocols. The safety of infrastructures was also found to be suboptimal, with ground floors and basements used to store materials or electrical stations and insufficiently powerful generators to cover the power outages resulting from the impact of the floods.

Among the most relevant recommendations proposed by interviewees, are the elaboration of integrated plans between the health system and the Civil Protection system, the improvement of the command-and-control system for emergency management within the health sector, the development of a clear and detailed guidance on how to map and manage fragile and vulnerable individuals and their evacuation in case of floods, and the delineation of directives at the local level on how to handle spontaneous volunteers' influx in emergencies. Investments in capacity building for health staff were also encouraged, through train-the-trainer mechanisms, simulations and exercises, and specific training on soft skills during crises.

5.2. Alert and activation

Key informants reported several challenges faced in the activation phase, including: i) lack of a systematic mapping of available resources (supplies, equipment, beds, human resources, etc.) and of fragile and vulnerable individuals at the local level; ii) fragmentation of existing databases and a lack of integrated platforms for information sharing between organisations, iii) surge in emergency calls and difficulty in prioritising the social and health needs at the population level due to insufficient human resources in the field, iv) lack of unified guidance on how to handle evacuations (immediate vs. preventive), v) ineffectiveness of the mobile phone application for alerts, vi) reluctance of citizens to leave their homes, and vii) initial delays in implementing a flow monitoring system in reception centres.

To overcome these issues, interviewees proposed the elaboration of a clearer operational definition of fragility in the context of EWEs, the enrichment of medical databases with information regarding social status, and the integration and sharing of such databases among all entities involved in the response. Interviewees also recommended undergoing a mapping process of all third-sector entities involved in the response, with the creation of a database for enhancing future surge capacity efforts and implementing an alert system capable of reaching a broader fringe of the population.

5.3. Response

One of the main limitations reported is the fragmentation of the response, both geographically and in terms of professional compartmentalisation within the health sector. Difficulties in handovers were also mentioned due to rotating operators, and overload in some operations centres that could not handle all population requests. Regarding human resources, understaffing and suboptimal preparedness to manage disasters were reported. Some obstacles in service delivery have been mentioned too, such as hindrances to healthcare services delivery due to certain facilities being designated for the evacuation of vulnerable individuals, delays in transportation due to overloaded ambulances, and delays in implementing a specific surveillance system. Important challenges concerned the management of different types of volunteers (organised vs. spontaneous) and the excess of volunteers arriving in some small, affected communities, which exceeded their management capacities.

The interviewees recommended the development of an information transmission system to optimise handover procedures among rotating operators, the drafting and dissemination of guidelines for spontaneous volunteers - so they know where to go, what to do, and what to bring, including Personal Protective Equipment (PPE), the promotion of mechanisms of task-shifting among healthcare workers, the implementation of a readily deployable health surveillance system in emergencies through collaboration with sentinel physicians, and the promotion of local spontaneous volunteering to foster mutual aid processes for affected communities.

5.4. Recovery

As for the recovery phase, only some critical issues have been identified, but no recommendations have been formulated. Among the main issues are difficulties in managing sewage and special waste that exceeded the management capacities of the affected municipalities, delays in reimbursements to citizens, who lost their belongings and assets, facilities that housed vulnerable evacuees, and healthcare workers who worked overtime, and last the shortage of houses for citizens who were left homeless due to the floods.

6. Discussion

This study examined the actions taken in response to the floods in the Emilia-Romagna Region in May 2023, particularly in the Romagna area that was most impacted by the floods, by identifying best practices and areas needing improvement. The lessons learned in the context of this case study can be useful for other Italian regions and countries aiming to strengthen the resilience of their health systems in the event of floods.

The following sections examine some of the major issues that emerged from the study, relate them to existing evidence, and propose recommendations that can be implemented to enhance the response to future similar events. In conclusion, one of the major strengths in the health response to the floods is detailed to stress on best practices and lessons learned.

6.1. Infrastructural damage and organisational issues impacted health service delivery

Key informants reported various impacts on healthcare infrastructures: pre-emptively evacuated wards at risk of flooding, inundated daycare centres and nursing homes, flooded ground floors of facilities, with implications for electrical systems, and damaged diagnostic equipment such as CT scans and MRIs due to roof rainwater infiltration. This infrastructural damage led to delays and disruptions in service delivery, and patient transfers to other facilities.

Despite improvements in infrastructural resilience thanks to far-reaching initiatives such as the WHO Safe Hospitals Initiative [23] and the development of tools for measuring safety like the Hospital Safety Index [24], many health facilities are still widely impacted by disasters. Wiesehahn and Kaifie [25], 2024, surveyed 103 outpatient clinics affected by the 2021 floods in Germany, revealing that 97% experienced power failures, more than 50% encountered water supply damage, and 40% lost patient records, with 76% of clinics having to temporarily close.

In Italy, many healthcare facilities are obsolete, with 60% of structures built over 40 years ago. The age of facilities is significant because older structures are less capable of withstanding the growing impacts of climate change [26]. It is essential not only to invest in healthcare infrastructure safety [27] but also to enhance monitoring mechanisms and accountability processes to track infrastructure vulnerabilities nationwide. There is also a need to raise awareness to promote changes in practices and organisational aspects, such as avoiding the use of ground floors for electrical systems or to store drugs and consumables.

6.2. Scepticism about evacuation required additional efforts to protect people in high-risk areas

While early warning systems are effective and operational, communication of alerts and the community's ability to respond promptly are often suboptimal [28]. In the Romagna area, factors contributing to initial scepticism about evacuation included insufficient trust in authoritative messages with risk underestimation, diverse sources used for evacuation and alert communications, and citizens' reluctance to leave their homes to reach reception centres that were located far from their residences.

Scientific studies on evacuations have developed algorithms and applied models and frameworks to optimise the transfer of evacuees to various facilities during floods [29–31]; other studies explored perceptions, barriers and facilitators regarding evacuations [32], especially among vulnerable individuals. In the Romagna area, the effectiveness of issuing evacuation alerts through communications signed not only by authorities but also by primary care physicians—professionals who work closely with the population—underscores the importance of gaining public trust for effective emergency communication.

It is crucial to promote participatory processes and community engagement [28] to consolidate public health and risk messaging in emergencies. It is recommended to conduct future research evaluating the effectiveness of various strategies to encourage preventive evacuations in emergencies, comparing methods such as door-to-door communication, app notifications, press releases and phone calls, in contexts with varying sociodemographic and cultural characteristics.

6.3. The challenging identification of fragile and vulnerable individuals impacted evacuations

In anticipation of the floods in the Romagna area, it was challenging to identify all individuals requiring evacuation, including the fragile (e.g., those over 60, with pre-existing chronic conditions, technology-dependent) and those who became vulnerable to the potential impacts of the floods (e.g., healthy young individuals who are geographically isolated, have poor local language proficiency,

and limited understanding of the healthcare system). Key issues included the lack of universally shared definitions of fragility and vulnerability, the absence of pre-existing and readily useable databases for evacuation planning, and the fact that databases are often not integrated.

Sharing data about fragile individuals among agencies involved in disaster response is essential for obtaining a comprehensive view of territorial fragilities. This is widely recognized not only in emergencies [33] but also in ordinary times, where interoperability of health information systems has been shown to improve care quality and reduce costs [34]. Despite the International Organization for Standardization (ISO) promoting the development of databases and communication channels that enable the sharing of voice messages, data signals, and electronic data based on a standardised vocabulary to enhance interoperability [35], information systems for disaster management in Italy remain compartmentalised.

To improve future disaster management, it is useful to promote systematic, comprehensive, and up-to-date data collection and the development of platforms and systems for sharing bio-psycho-social health information about individuals. This would allow various components of the health system to integrate their data with those from social services and third-sector organisations operating in the field for rapid identification of people that require prompt evacuation.

6.4. Rising social and health needs required cooperation between primary care and social services

Several factors influence the type of health needs that emerge after floods, including the type of flood, the geography of the affected area, the demographics of the impacted population, community infrastructures, and the disaster management system [36]. In the case of the Romagna area, hospitals experienced minimal impact from patient influx, while most needs were of a social and primary care nature, requiring substantial efforts from primary and community care, and social services. Primary care had to reorganise service delivery models, reallocating personnel to reception centres and PASS to replace flooded clinics.

Although the Emilia-Romagna Region has long-standing experience in primary and community care, with an advanced network of operational community health centres—approximately 25 % of all such centres in Italy [37]—gaps in the disaster preparedness of the primary care system emerged. The importance of considering and promoting disaster preparedness in primary and community care systems was highlighted as early as the floods in Obrenovac, Serbia, in 2014 [38]. Following the COVID-19 pandemic, awareness of the importance of preparing primary care to respond to disasters has increased, leading to the development of new frameworks and tools [39–41].

Yet, resources and directives aimed at strengthening the preparedness and resilience of hospitals still predominate over initiatives that consider the primary care system. Given factors such as the increasing frequency and intensity of EWEs and the global ageing population, it is crucial to monitor the preparedness of primary care alongside hospitals, and to promote exchange, training, and simulation opportunities that allow professionals at all levels of care to interact and cross-contaminate with knowledge from other divisions.

6.5. Compartmentalisation hindered initial response cohesiveness

Although Italy and the Emilia-Romagna Region are prone to floods [42], key informants reported the absence of shared, hazard-specific plans and protocols that integrate the activities of all agencies involved in disaster response, including Civil Protection, basin authorities, and the healthcare system. While each agency has internal guidelines, these fall short when it comes to processes that need to be jointly managed, such as evacuations or spontaneous volunteers' coordination.

Our study's findings partially echo those from Landeg et al. [43] on the floods that affected Boston, Lincolnshire (United Kingdom) in 2013. The authors stated that the fragmentation of health services challenged governance, oversight, and the development of coherent strategies. Although diversification is key to enhancing disaster resilience, diversifying strategies and practices in risk management can lead to fragmentation, with responsibilities distributed among various actors and potentially reducing the effectiveness of the response [44].

Thus, for effective disaster response, it is crucial to identify figures that centralise the management of key processes in disaster response. In the case of the Romagna floods, these figures included the bed managers, responsible for coordinating evacuation processes; health district directors, who served as points of reference for coordinating various local bodies; the social services, which managed aid requests and communicated with the regional control centre for transferring individuals; the emergency services operations centre, which facilitated informational and decision-making centralization, thus aiding the coordination of the medical response.

6.6. Large influx of spontaneous volunteers called for a collaboration with external agencies

Volunteers are a scalable resource, essential for activating surge capacity during disasters. The use of the internet and social media has facilitated information sharing about disasters, enabling citizens to autonomously organise informal rescue groups and provide support in affected areas. Despite being indispensable, spontaneous volunteers often lack technical training, making them less effective than highly professionalised disaster response teams [45]. Volunteers may also arrive in excess, possibly posing the system to the following risks: underutilisation of human resources due to disparities between workforce and needs, challenges in restricting volunteer activities to safe areas, potential conflicts between spontaneous and organised volunteers, and health risks (e.g., trauma, skin infections) in the absence of personal protective equipment.

The different provinces impacted by the floods in the Romagna area demonstrated varied approaches to managing spontaneous

volunteers. A particularly effective approach concerned the involvement of an external NGO that managed volunteer groups coming into the affected areas; NGO staff also facilitated the integration of efforts between organised volunteer groups (e.g., Civil Protection, Red Cross) and spontaneous volunteers. In line with this approach and existing evidence on spontaneous volunteers' management, a more structured involvement of volunteers in emergencies is recommended, while leveraging the utility of spontaneous volunteers by encouraging local mobilisation to strengthen self-help mechanisms and promote post-traumatic growth [46,47].

Notably, in this regard, the International Organization for Standardization (ISO) issued guidelines (ISO/CD 22319:2017) in 2017 for the planning and integration of spontaneous volunteering in disaster response and recovery [48]. However, the interviews revealed that these guidelines are not yet widely disseminated or well-known. To date, volunteer management remains largely unstructured and lacks standardisation. It underscores the need for existing guidelines, such as ISO/CD 22319:2017, to be incorporated into national and/or regional plans and adapted to specific contexts to ensure practical implementation.

6.7. Existing networks and mutual trust facilitated cooperation for effective response

A crucial aspect of the response to the Romagna floods was the reliance on an informal network that facilitated collaboration among professionals from various fields. A key element was the presence of an established trust relationship prior to the floods, partly stemming from the networks established for the management of the COVID-19 pandemic, which enabled the strengthening of collaborations in emergency situations. In Faenza, the synergy between a local authority and a third-sector organisation served as an example of effective cooperation, demonstrating the feasibility of maintaining centralised coordination even when support is sought from external bodies [49].

The sense of belonging, the strong desire for recovery, a well-established network of relationships and collaborations with multiple local actors, and a system of primary and territorial care among the most advanced in Italy significantly contributed to the disaster response. Although these strengths reflect the identity of a cohesive area like Romagna, they can be transferred to other Italian regions or international contexts through ongoing training and cross-sectoral simulations. These activities not only support the implementation of plans and protocols, but also foster the spread of a system-oriented culture, emphasizing the importance of getting to know each other, thus building a network of interpersonal and cross-sectoral relationships that are essential for improving the effectiveness of disaster response.

This study has both strengths and limitations. A best practice that is worth outlining is the collaboration between a Local Health Authority and an academic institution to conduct an evidence-based comprehensive review of the actions taken in response to the floods. Performing After Action Reviews and identifying areas for improvement is essential for Building Back Better [50], advancing system resilience, and for self-assessment and collective learning. The broad definition of "health system" employed in this study facilitated a comprehensive analysis of all elements within a complex response framework. The methodology, which involved in-depth interviews, provided a detailed investigation of the challenges reported by participants, leading to a thorough set of findings and an insightful perspective on the events. Among the limitations, there is the need to complement these findings with future epidemiological investigations into local health records to gain a more comprehensive understanding of the health system functioning during floods. Additionally, it is important that future studies also explore the perspectives of affected citizens and communities, to gain insights into their views on the response to the floods.

7. Conclusion

In May 2023, the Romagna area experienced two severe rainfall events leading to widespread flooding across urban areas, with significant impacts. The coordinated response involved various agencies, including the Civil Protection, the health system, social services, and third-sector organisations. This in-depth retrospective qualitative study aimed to assess the health response to the floods, revealing both best practices and areas for improvement. Findings emphasised the strain on the healthcare system, including disruptions to services and infrastructure. Actions that were undertaken in response to the floods have been explored and categorised in different phases, providing a thorough overview of disaster response strategies at the local level. Recommendations include enhancing information sharing for disaster management, improving coordination of evacuations of fragile and vulnerable individuals, and strengthening volunteer management. The study underscores the value of interdisciplinary collaboration and the need for continuous evaluation to improve disaster response and resilience.

CRediT authorship contribution statement

Martina Valente: Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Clara Del Prete:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Giulia Facci:** Writing – original draft, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Ardigò Martino:** Writing – review & editing, Validation, Supervision, Conceptualization. **Giuseppe Roberto Grilli:** Writing – review & editing, Validation, Supervision, Conceptualization. **Francesca Bravi:** Writing – review & editing, Validation, Supervision. **Chiara Reno:** Writing – review & editing, Writing – original draft, Validation, Data curation. **Luca Ragazzoni:** Writing – review & editing, Validation, Supervision, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ijdrr.2024.105089.

Data availability

Data will be made available on request.

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