GNGTS 2024

DISASTER RISK ANALYSIS AND REDUCTION

Session 2.3

Risk Communication

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Interventions can address – but are not limited to – the following areas and topics:

- **Information and communication technologies for risk and crisis communication (e.g., social media, citizen sensors)**
- **Relationship between risk perception and communication**
- **Risk communication and behavioural change**
- **Multi-hazard risk communication**
- **Risk communication for disaster prevention, preparedness, response, and recovery**
- **Targeted risk communication (i.e., involving diverse groups such as vulnerable populations, young people, and gender-sensitive communication)**
- **Risk education**
- **Ethics in risk communication.**

Risk and crisis communication is an essential component for disaster risk prevention and management and, to be effective, it requires multidisciplinary and multi-actors efforts. Risk communication should therefore be implemented in all the phases of the disaster cycle (e.g. prevention, preparedness, response and recovery). This session welcomes contributions from researchers and practitioners working on different research streams and hazards from a multi-hazard risk perspective. Relevant topics include -but are not limited to – opportunities offered by information and communication technologies for tailoring the message to the specific needs of diverse groups and sub-populations; social media and social construction of risk; the role of risk education in communication; drivers of risk perception and behavioural change.

Towards the IT-ALERT implementation. Early warning and cell-broadcast systems in the context of risk and crisis communication

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Introduction

Communication is one of the most effective - and at the same time complex - processes to mitigate risks to the population. Indeed, it allows protecting the safety of citizens in peacetime: following an ongoing process (Coombs, 2007; Palttala & Vos, 2012) that, through the timely activation of relational practices and (in)formative processes involves institutions, citizenship, and the media (Zimmerman, 1987; Johnson, 1999; Comunello, 2014; Cerase, 2017; Comunello and Mulargia, 2017; Renn, 2020; Rafliana et al., 2022) or-as in the specific case study-a few minutes or seconds before a damaging event hits the population (WMO, 2022).

Technological progress has actually transformed the communication of anthropogenic and natural hazards. This has engaged institutions, and still requires them energy and effort, to identify the "communicative optimum" time after time, trying to identify the best strategies to disseminate information including through Social Network Sites (SNS) (Stieglitz & Dang-Xuan, 2013; Alexander, 2014). In this framework, driven by the widespread use of mobile devices, the United Nations Foundation (2010) argues that: "if communities, to survive in times of crisis, depend on information, then communication technologies constitute their lifelines."

The online environments activate seamless communicative dynamics (Baym, 2015) that engage citizens in an active role in terms of demands towards risk management institutions (Kasperson & Kasperson, 2012). The direct, two-way exchange, in which SNS and platforms are seen as discussion environments, has required further adaptation of communication modalities both on the part of the institutions responsible for risk communication and from the point of view of scientists, researchers, local managers, and stakeholders dealing - at various levels - with risks, in order to respond clearly, punctually, quickly, and, possibly, by personalizing the response, for citizens who in an "always on" (Baron, 2008) perspective become "prosumers" of information and knowledge.

As for risk communication, citizens, driven by growing information needs in peacetime as well as in crises, rely on the information and answers they find on the web (verified or not). In our case,

these needs are mainly to be found in the spheres of cognitive needs, to obtain information about risks independently, and of integrative personality needs to search for post-emergency information should they be involved in a disaster event (Wachinger et al., 2013). In this case, one of the strengths that enabled the self-information of online environments to reach the general public sooner also concerns regulatory management.

While the early warning broadcast systems provide for centralized management with a strong normative and accountability component - as well as relevant technological systems managed by experts in the field - (Valbonesi et al, 2019,2021) the internet is not jurisdictional with regard to the sharing of communicative content except from the point of view of data protection, and mild regulations exercised by private individuals operating SNSs, it is multi-modal and the communication that takes place in it is self-generated in terms of content, self-directed in terms of emission mechanisms, and self-selected in terms of reception.

The Early Warning System for Natural Hazards

Early warning systems (EWS) are part of the risk communication framework. According to the 2006 report of the United Nations General Office for Disaster Risk Reduction (UNDRR), communication is one of the four components of an EWS together with risk knowledge, monitoring, warning and message dissemination.

In 2017, the UNDRR defines an early warning system as *"An integrated system of hazard monitoring, forecasting and prediction, disaster risk assessment, communication and preparedness activities systems and processes that enables individuals, communities, governments, businesses and others to take timely action to reduce disaster risks in advance of hazardous events".* The provided definition actually follows point-by-point the alert process, which needs specific instruments and expert human resources to be issued.

For this study proposal, rather than the systems and protocols for sending/receiving the message, I will focus on the socio-demographic, gender, cultural and livelihood aspects of the recipients, in order to better target users' actions according to the alert and facilitate the operations of emergency managers.

For this I started from a preliminary survey conducted in New Zealand by J. Becker et al. where, as of 2020 - the year of the study - an early warning system for earthquakes had not yet been implemented. Becker's team, in that context, conducted a survey of the public's acceptability, attitudes and perceptions regarding the development and reception of earthquake early warnings, before the government decided to invest money in the technology. The interviewees in that case expressed a positive opinion about the system, suggesting some substantial information regarding, for example, the warning threshold, the actions they would take within a few seconds before they felt the earthquake and those they would take within a few minutes before the tremor started. An applicable and replicable methodology, useful to produce relevant and directly usable information for risk mitigation institutions.

Cell-broadcast warning systems and IT-ALERT as case studies

To date, broadcast technology represents the most stable and reliable communication channel even in emergency situations. The broadcast communication flow actually involves: the signal source through which the process begins, the modulation or transformation of the signal into a transferable format, the transmission through a medium that carries the signal, the reception by devices in the network and capable of receiving the specific signal, the demodulation or decoding that allows the signal to acquire its original format again, and the reproduction or display of the initial message. Widely used and recognised throughout the world, broadcast technology recognises and supports the C.A.P. (Common Alerting Protocol), which is an international standard initially used in the military field and now adapted to the communication of emergency alerts and alarms. Among the strengths of the C.A.P. protocol is firstly the interoperability that allows the same message to be decoded by different devices and platforms, and secondly the simplicity and, if desired, schematic nature of the message. European Directive 2018/1972 of 11 December 2018 establishes the European Electronic Communications Code (EECC). Article 110 of the EECC makes it mandatory that as of 21 June 2022, when public warning systems are in place, "in the event of imminent or ongoing major emergencies and disasters, providers of mobile interpersonal communication services, based on the mobile phone number, shall transmit public alerts to the end users concerned". The legislation is not mandatory regarding the setting up of public warning systems, although it regulates the character of the warning.

In Italy, to date, no official channels are in place to issue rapid emergency information. There are also several apps made by third-party developers that, with different application interfaces and in different contexts, have been adopted by various municipalities. The Italian Presidency of the Council of Ministers, with the directive of 7 February 2023, decides the experimentation, on the Italian territory, of the IT-Alert public alert system with reference to the Civil Protection activities in order to conform the alerting procedures to the above-mentioned European regulations (G.U. Serie Generale n.91 of 18-04-2023).

The IT-Alert system, which is now operational, will directly inform the population at risk by sending an information message to geographically located mobile phones. Users, in order to receive the message, will need to have their mobile phone and - for now - the public alert messaging service, in the mobile phone's settings, active.

Below are some preliminary percentage frequencies extracted from the questionnaire administration test on 13.12.23 at the Information Engineering Faculty of the Università Politecnica delle Marche. 114 questionnaires were collected for the test. For this specific research, an ad-hoc section was added to the questionnaire developed by Backer et al. in New Zealand to survey some of the respondents' opinions about IT-ALERT.

- 86% of the respondents know IT-ALERT, 14% are not.
- 71% received the system test message, 29% did not.

- More than 50% of the respondents affirmed that one test was not enough to be clear about how IT-ALERT works.
- About 80% of the respondents wouldn't feel anxiety if they received an alert message sent by the IT-ALERT system.
- Most respondents knew IT-ALERT through social media or through the Civil Protection's testing of the system.

References:

Alexander, D. E. (2014). Social media in disaster risk reduction and crisis management. Science and engineering ethics, 20, 717-733.

Baron, N. S. (2008). Always on: Language in an online and mobile world. Oxford University Press. http://dx.doi.org/10.1093/acprof:oso/9780195313055.001.0001

Baym, N. K. (2015). Personal connections in the digital age. John Wiley & Sons. ISBN: 978-0-745-67033-1

Becker, J. S., Potter, S. H., Vinnell, L. J., Nakayachi, K., McBride, S. K., & Johnston, D. M. (2020). Earthquake early warning in Aotearoa New Zealand: A survey of public perspectives to guide warning system development. Humanities and Social Sciences Communications, 7(1), 1-12. https://doi.org/10.1057/s41599-020-00613-9

Cerase, A. (2017). Rischio e comunicazione Teorie, modelli, problemi. Rischio e comunicazione Teorie, modelli, problemi, 1-290.

Comunello, F. (ed.) (2014). Social media e comunicazione d'emergenza, Guerini e Associati, Milano.

Comunello, F., Mulargia, S. (2017). Tra risposte protocollate e «social sensing». L'uso dei social media per la comunicazione d'emergenza nelle istituzioni locali italiane in "SOCIOLOGIA E RICERCA SOCIALE " 112/2017, pp 111-137, DOI: 10.3280/SR2017-112006

Coombs, W. (2007). Protecting Organization Reputations During a Crisis: The Development and Application of Situational Crisis Communication Theory. Corp Reputation Rev 10, 163–176. https://doi.org/10.1057/palgrave.crr.1550049

G.U. Serie Generale, Anno 164° n.91 del 18-04-2023 http://www.gazzettaufficiale.it/eli/gu/2023/04/18/91/sg/pdf

Johnson, B. B. (1999). Ethical issues in risk communication: Continuing the discussion. Risk analysis, 19, 335-348. https://doi.org/10.1023/A:1007084108903

Kasperson, R. E., & Kasperson, J. (2012). Social contours of risk: Volume I: Publics, risk communication and the social. Routledge. ISBN 978184407073

Palttala, P., & Vos, M. (2012). Quality indicators for crisis communication to support emergency management by public authorities. Journal of Contingencies and Crisis Management, 20(1), 39-51. https://doi.org/10.1111/j.1468-5973.2011.00654.x

Rafliana, I., Jalayer, F., Cerase, A., Cugliari, L., Baiguera, M., Salmanidou, D., ... & Hancilar, U. (2022). Tsunami risk communication and management: Contemporary gaps and challenges. International Journal of Disaster Risk Reduction, 70, 102771. https://doi.org/10.1016/j.ijdrr.2021.102771

Renn, O. (2020). Risk communication: Insights and requirements for designing successful communication programs on health and environmental hazards. In Handbook of risk and crisis communication (pp. 80-98). Routledge.

Stieglitz, S., & Dang-Xuan, L. (2013). Social media and political communication: a social media analytics framework. Social network analysis and mining, 3, 1277-1291.

UNDRR (United Nations for Disaster Risk Reduction). (2006). Developing early warning systems: from concept to action. A checklist. Third international conference on early warning, United Nations (UN), Bonn, Germany. https://www.undrr.org/quick/10879 accessed 21 August 2023

UNDRR (United Nations International Strategy for Disaster Reduction). (2015). Sendai framework for disaster risk reduction 2015–2030. A/CONF.224/CRP.1. Geneva, Switzerland. https://www.undrr.org/quick/11409

United Nations Foundation (2010). New technologies in emergencies and conflicts report: The role of information and social networks (New York: United Nations Foundation, 2010).

Valbonesi, C., Amato, A., & Cerase, A. (2019). The INGV Tsunami Alert Centre: analysis of the responsibility profiles, procedures and risk communication issues. Bollettino di Geofisica Teorica ed Applicata. https://doi.org/10.4430/bgta0252

Valbonesi, C. (2021). Between necessity and legal responsibility: the development of EEWS in Italy and its international framework. Frontiers in Earth Science, 9, 685153. https://doi.org/10.3389/feart.2021.685153

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013). The risk perception paradox—implications for governance and communication of natural hazards. Risk analysis, 33(6), 1049-1065.

WMO (World Meteorological Organization) (2022). Early Warning and Anticipatory Action. In Bulletin Vol. 71 (1). http://public.wmo.int/en/resources/bulletin accessed 14 Dec 2023

Zimmerman, R. (1987). A process framework for risk communication. Science, Technology, & Human Values, 12(3/4), 131-137. http://www.jstor.org/stable/689393

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Tsunami Ready: some steps for a people-centred tsunami risk approach

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Abstract

The Tsunami Ready (TR) programme, developed in the United States of America by the US National Weather Service (NWS) and the National Ocean and Atmospheric Administration (NOAA), is aimed at ensuring greater tsunami risk awareness and more effective tsunami risk management by coastal communities, which are called to take an active role in the definition and implementation of life-saving measures. The UNESCO International Oceanographic Commission, assuming the programme as one of its main objectives, has developed international and standard guidelines for the accreditation of individual municipalities wishing to be declared “Tsunami Ready”. The guidelines, based on decades of experience in protecting coastal communities from tsunami risk, have been tested in various tsunami-prone regions around the world (UNESCO, 2022). The Tsunami Ready programme has been identified as a priority in the framework of the Ocean Decade for Sustainable Development, established by the United Nations for the period 2021-2030 (Franke et al., 2023).

A detailed, universally applicable - and traceable - grid consisting of three thematic sections and 12 indicators underpins this approach.

	TSUNAMI READY INDICATORS
I	**ASSESSMENT (ASSESS)**
1	**ASSESS-1**. Tsunami hazard zones are mapped and designated.
2	**ASSESS-2**. The number of people at risk in the tsunami hazard zone is estimated.
3	**ASSESS-3**. Economic, infrastructural, political, and social resources are identified.
II	**PREPAREDNESS (PREP)**
4	**PREP-1**. Easily understood tsunami evacuation maps are approved.
5	**PREP-2**. Tsunami information including signage is publicly displayed.
6	**PREP-3**. Outreach and public awareness and education resources are available and distributed.
7	**PREP-4**. Outreach or educational activities are held at least 3 times a year.
8	**PREP-5**: A community tsunami exercise is conducted at least every two years.
III	**RESPONSE (RESP)**
9	**RESP-1**. A community tsunami emergency response plan is approved.
10	**RESP-2**. The capacity to manage emergency response operations during a tsunami is in place.
11	**RESP-3**. Redundant and reliable means to timely receive 24-hour official tsunami alerts are in place.
12	**RESP-4**. Redundant and reliable means to timely disseminate 24-hour official tsunami alerts to the public are in place.

Table 1: Tsunami Ready programme indicators

Among the strengths of the programme is the voluntary, performance-based community recognition to promote prevention and preparedness through the active collaboration of national and local civil protection agencies, land management authorities, scientists and citizens. Therefore, Tsunami Ready can be considered in a mixed-methods framework. Besides a methodology based on standard indicators, there is an underlying qualitative approach that promotes interaction and participation between the various parties involved at various levels. These principles are embedded both between the SDGs of the UN 2030 agenda and Sendai Framework for Disaster Risk Reduction to “Make cities and human settlements inclusive, safe, resilient and sustainable” and to highlight the need to invest in, develop, maintain and enhance multi-hazard, multi-sectoral early warning and forecasting systems (UNISDR, 2018). Such systems should be user-oriented, adopting a participatory, people-centred approach, and include effective risk communication mechanisms in disaster and emergency situations. In table below we condensed the strengths and criticalities emerged from the application (described below).

Strenghts	Problems/Criticalities
A clear strategy with a finite number of objectives (12)	Careful definition of the inundation areas (need for detailed DTM and local scale modeling)
The international (IOC-UNESCO) framework limits the sphere of possible liability of local authorities and collaborators /scientists	Bureaucracy (Mayor’s election, complex purchase procedures, …)
Inducement to risk education for young citizens (schools)	Funding (specific resources not available, must be allocated)

Strenghts	Problems/Criticalities
Inducement to formation and information for the population, including the attitude towards a self protective approach	Competition with other more frequent hazards (floods, storms, fires, earthquakes) and local problems (traffic, streets conditions, seaside facilities management, …)
Motivation for a multi-risk approach	Difficulty in spreading TR to tens/hundreds coastal localities without a continuous support by scientific and CP experts (reaching the Ocean Decade target of 100% within 2030)

Table 2: strengths and weaknesses for the Tsunami Ready programme

In Italy, the Tsunami Ready initiative was launched in 2020-2021 with the establishment of the National Committee (composed by the National Department of Civil Protection, ISPRA and INGV) and the identification of three pilot coastal municipalities (Valbonesi, 2022).

The first three coastal municipalities to join the Tsunami Ready programme are: Minturno, in southern Latium, Palmi in Calabria and Pachino/Marzamemi in Sicily. In 2023, the Municipality of Otranto (LE) in Apulia also joined the programme. We are currently waiting for the municipal resolution of the municipality of Lipari (ME), which will join the programme with Stromboli Island.

The Italian coastal municipalities that joined the program are located in different areas of the peninsula, these areas also differ among themselves in I) tsunami hazard II) urban and environmental context III) socio-demographic composition.

Municipalities involved in achieving recognition have enthusiastically embraced the initiative and are moving forward, even if at different speeds, point by point through the grid indicators. Below we provide a summary map with some photographic and detailed elements for the initiatives that, to date, have actively involved the population (at various levels) in the pilot sites (Amato et al., 2023).

Italian National Tsunami Ready Board: Dec 15, 2023

A- Minturno, Latium, Pop. 19,700 Medium-Low Hazard Local TR Board: 03/2021

B- Palmi, Calabria, Pop. 17,000, Medium-High Hazard, Local TR Board: 12/2020

C- Marzamemi-Pachino, Sicily, Pop. 376 / 21,000, Ionian - High Hazard, Local TR Board: 04/2021

D- Otranto, Apulia, Pop. 5,769, Adriatic - High Hazard, In progress (2023)

E- Stromboli volcano, Tyrrhenian sea, Pop. 450 / n,000 (summer), High Hazard , In progress (2023)

References:

Amato, A., Valbonesi, C., Cugliari, L., Graziani, L., & Romano, F. (2023). Tsunami Ready in Italy: towards the UNESCO recognition (No. EGU23-15864). Copernicus Meetings.

Franke, A., Peters, K., Hinkel, J., Hornidge, A. K., Schlüter, A., Zielinski, O., ... & Hillebrand, H. (2023). Making the UN Ocean Decade work? The potential for, and challenges of, transdisciplinary research and real-world laboratories for building towards ocean solutions. People and Nature, 5(1), 21-33. https://doi.org/10.1002/pan3.10412

UNESCO (2022). Standard guidelines for the Tsunami Ready Recognition Programme. IOC/2022/MG/74. https://unesdoc.unesco.org/ark:/48223/pf0000381353

UNISDR United Nations Office for Disaster Risk Reduction (2018). Global Capacity Development Strategy to Support Implementation of the Sendai Framework for Disaster Risk Reduction, 23 February 2018, https://www.preventionweb.net/files/56922_sfdrrcdstrategyzerodraft20180223.pdf

Valbonesi, C. (2022, May). Tsunami Ready Programme in NEAM region: strategies, responsibilities and further advancements to protect communities from tsunamis. In EGU General Assembly Conference Abstracts (pp. EGU22-11876).

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“A Scuola di Terremoto”: a targeted risk education project in Calabria (South Italy) to promote behavioural change

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1. The project “A Scuola di Terremoto”

“A Scuola di Terremoto” (“At Earthquake School", in the following ASdT) is a seismic risk education project addressed to secondary schools and aimed at offering both educational training for teachers and activities with students in the classroom. The goal is to motivate, deepen, and consolidate knowledge throughout an occasion of “discovery”, where reflection and engagement can lead to a better understanding of the concept of earthquakes.
Based on more than 20 years of experience within Edurisk (www.edurisk.it), we designed the ASdT project to raise awareness among teachers and their students about seismic risk and the possible consequences of an earthquake, and to create a network of shared experiences throughout schools in the region.
The project started in February 2022 and continued and refined in the following year. The data presented here refer to the status of the project at the end of the 2022-2023 school year. The activity is currently underway for the 2023-2024 school year, with well-established methods and activities (Fig.1). The project was promoted by the Calabria Region, which is well aware of seismic hazard and the high level of risk in its territory (Camassi, 2008).

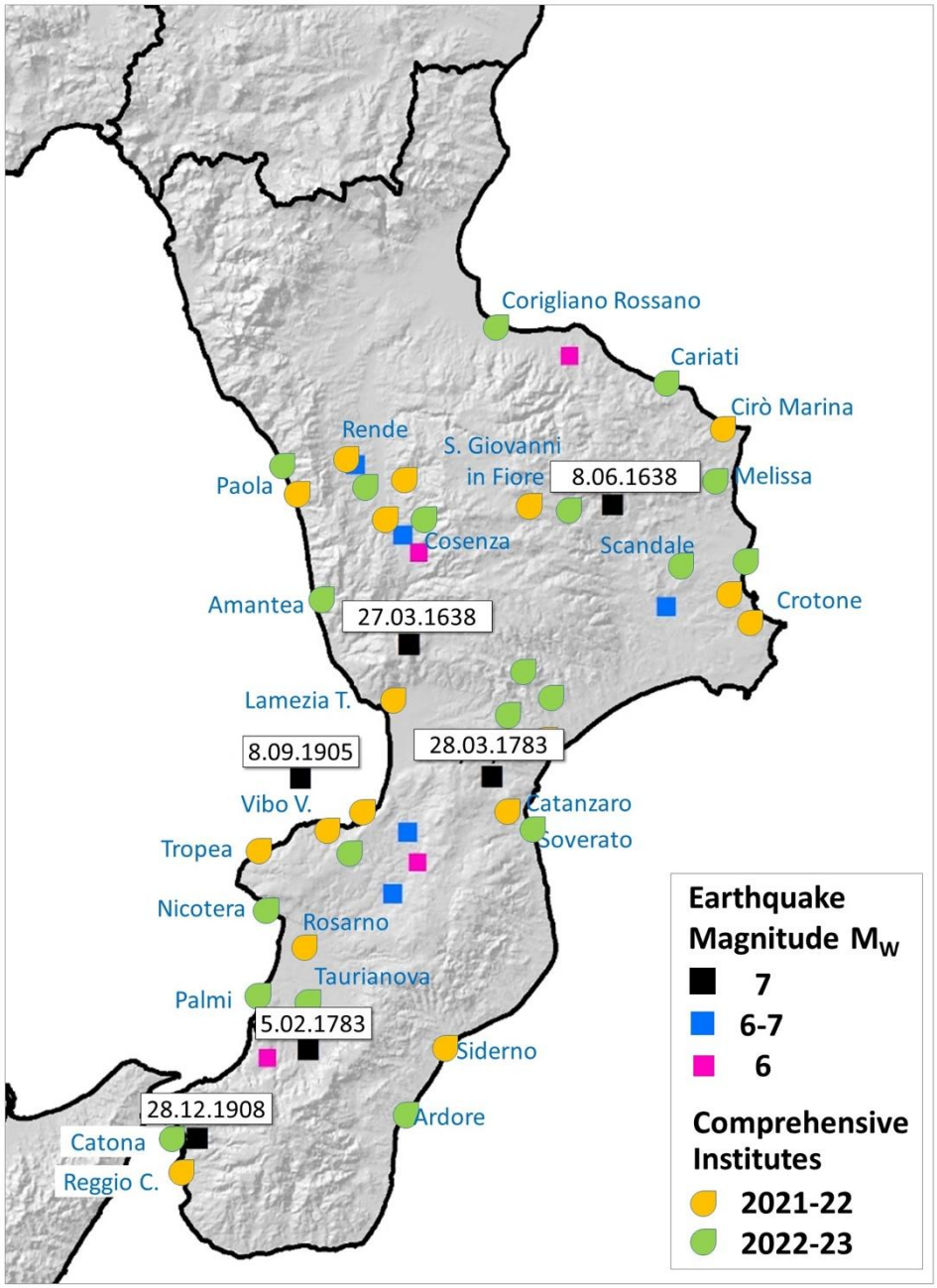

Fig.1 - Map of the Comprehensive Institutes participating in the ASdT project and distribution of the major historical earthquakes in Calabria (data from CPTI15, Rovida et al., 2021)

2. The numbers of the project

2.1. Experimental phase (AS. 2021-2022)

The project initiated in February 2022 and, thanks to the close collaboration with the Regional School Office of Calabria, it involved 41 teachers, 17 classes, and 17 Comprehensive Institutes (Tab. 1).

According to the Italian school system, nursery, primary and lower secondary schools, close to each other in the area and connected for administrative purposes, are brought together in a single Comprehensive Institute (Istituto Comprensivo), that is a multi-sit school. Outside the cities and the most populated centres, the Comprehensive Institutes can gather schools of even 5-6 municipalities, and also have a dozen or more schools buildings ("plesso").
The project is structured in two main parts: in the first we proceed with the training of teachers through three dedicated meetings of a couple of hours each.
The first meeting was held in Calabria where the ASdT team was present in three different locations in the area to give all teachers a chance to participate (Fig. 2, left); the other two training meetings were held remotely, in afternoon-evening hours, to meet the needs and availability of teachers.
The other part of the project took place directly in classrooms: the ASdT team organized playful, interactive and multidisciplinary workshops with the support of teachers. Again, the first workshop in the classrooms was carried out in person (Fig. 2, right), while the other two were carried out remotely, agreeing on the relevant schedule with the teachers.

Fig.2 - Teachers training (left) at Siderno (Reggio Calabria) and workshops in the classrooms (right) on March 2022

2.2. Refinement phase (AS. 2022-2023)

With the start of the 2022-2023 school year, we worked to refine the educational programming and extend the network of involved schools. We held a series of meetings open to all teachers to present the overall project. Almost all Comprehensive Institutes activated in 2021-2022 decided to continue the project, and 21 new institutes joined the existing network with the involvement of 58 teachers and 45 classes. Among the new institutes were some upper secondary schools for which ad hoc activities had to be planned (Tab. 1).

2.3. Current activities (AS. 2023-2024)

The project is currently underway in 20 Comprehensive Institutes (Tab. 1). Some of the schools that have already participated (8) have proposed to continue the activity in new classrooms and

have shown interest in training new teachers (49). 12 schools, however, are joining for the first time.

Tab. 1 – Number of involved Comprehensive Institutes

Scolastic year	Comprehensive Institutes	Trained teachers	Classes with an avarage of 20 students/classe
2021-2022	17	41	17
2022-2023	21	58	45
2023-2024	20	49	--

Training courses for teachers and activities with students

The three training meetings for teachers covered the following topics:

Some activities were proposed to check motivations for participating in the project, and others to discuss and compare their own views of the earthquake. Techniques such as discussion and role-playing games were used that can be replicated later by teachers in classroom activities. The initial meeting aimed to bring out the questions they personally considered most important and the most sensitive topics, which were then discussed in subsequent meetings.

The second meeting aimed to understand how to build knowledge about the earthquake by delving into the topic of earthquake risk. Through the flipped classroom model (Bergmann and Sams, 2012; Maglioni and Biscaro, 2014), some important topics were explored in depth through the use of scientific models, historical documents, scientific documentation and discussions with "experts." Teachers then brainstormed and shared the information gathered.

Finally, with work developed in small groups, the topic of educational planning was addressed, building and sharing working hypotheses to be implemented in classrooms.

The activities proposed to students in the classrooms are the following:

The workshop on risk was proposed in the form of a comparison game. Two stories of common life situations (a walk in the woods and a trip to the mountains) are presented in which risky conditions are included. The students' behaviour choices become an opportunity to confront each other on the different propensity and acceptance of the level of risk, and respect for rules to safeguard themselves and the community

The second workshop was devoted to exploring the imagery of the earthquake (how it occurs, what is its impact, how people react) through the invention of stories, illustrated and described by

the students. Through this work, they had the opportunity to show what they know or imagine about earthquakes and to represent what the occurrence of an earthquake means, questioning its possible consequences in both the short and long term.

A key element of the project is to increase students' and adults' awareness of the hazard characteristics of the area where they live, and thus its seismicity and seismic history. For this reason, in the third workshops, students were invited to collect testimonies and memories of family members or acquaintances related to seismic experiences.

4 Conclusions

After the initial calibration phase that saw an important presence of the ASdT team in the Calabrian territories for a couple of years, the project is now being organized to be self-sustainable and easily reproducible for all Calabrian schools.

The constant demand for participation from schools (this year the number of schools has increased) and the enthusiasm shown by teachers who have already participated and are renewing their presence, suggest the goodness and quality of the educational proposal. This finding is not surprising because the educational proposal is consistent with the philosophy of Edurisk, which for more than 20 years has been offering training to teachers to be able - together - to educate students (Pessina and Camassi, eds., 2012; Camassi et al. 2016). This approach has also proven effective in recent experiences in other Italian territories in the northern Apennine area (Camassi et al., 2021; Ercolani et al., 2022).

Frontal lectures, imparting notions, were banished, but mutual acquaintance activities were proposed to assess the teachers' level of knowledge and degree of curiosity and interest. Students were offered active-learning laboratory activities with the involvement of families and relatives.

Wide-ranging topics were covered, from the concept of generic risk to seismic issues, dropped into the local reality, albeit with due local difference.

In fact, one of the ultimate goals of this project is to provide an opportunity to verify personal experiences within one's family or social context: people are invited to search for traces of past earthquakes (recent or otherwise), through memories or signs on the territory for full awareness leading to risk reduction choices.

Greater knowledge of risks and preventive measures can make the difference between an effective response to an earthquake and a disaster situation. Awareness campaigns through schools help identify specific community needs and customize awareness strategies, stimulating collective efforts to minimize risks.

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References

Bergmann J., Sams A.; 2012: Flip Your Classroom: Reach Every Student in Every Class Every Day. International Society for Technology in Education, Washington DC, 112 pp.

Camassi R.; 2008: Educazione e Rischio a cento anni dal terremoto del 1908. 1908 - 2008 Scienza e Società a cento anni dal Grande Terremoto. Riassunti estesi del convegno, Reggio Calabria, 10-12 December, Miscellanea INGV, 3, pp. 25-26.

Camassi R., Ercolani E., Brasini F., Modonesi D., Pessina V., Castelli V., Meletti C.; 2021: One hundred years after: The results of an educational project, 37° European Seismological Commission General Assembly, ESC2021, Virtual, 19-24th September, Abstract ESC2021-S06-292

Camassi R., Pessina V., Bernardini F., Castelli V., Crescimbene M., Ercolani E., La Longa F., Nostro C., Pignone M.; 2016: EDURISK, 15 years of risk education, state of the art. 35th European Seismological Commission General Assembly, ESC2016, September, Trieste, Abstract ESC2016-667.

Ercolani E., Camassi R., Brasini F., Modonesi D., Castelli V., Pessina V.; 2022: Comunicare ed educare al rischio, le strade possibili. Quaderni di geofisica, 182, pp. 40, ISSN: 1590-2595

Maglioni M., Biscaro F.; 2014: La classe capovolta. Innovare la didattica con il flipped classroom. Erickson, 87 pp.

Pessina V., Camassi R. (eds); 2012: EDURISK 2002-2011: 10 anni di progetti di educazione al rischio. Roma, 30 novembre 2011. Miscellanea INGV, 13, 77 pp.

Rovida A., Locati M., Camassi R., Lolli B., Gasperini P., Antonucci A.; 2021: Catalogo Parametrico dei Terremoti Italiani (CPTI15), versione 3.0. Istituto Nazionale di Geofisica e Vulcanologia (INGV). https://doi.org/10.13127/CPTI/CPTI15.3

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Insights into risk communication from the analysis of earthquake light phenomena reports in Turkey and Morocco

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Recently, a 6.8-magnitude earthquake struck Morocco on September 8, 2023, at 11.11 p.m. local time. Video footage has emerged capturing unusual light phenomena during this seismic event. The first recording, Fig. 1a, available at https://www.albawaba.net/editors-choice/mysterious-blue-light-flashes-moroccan-earthquake-1533613, features blue flashes in Agadir originating from the ground. This video, dated 11.08 p.m. on September 8, 2023, was captured by a surveillance camera. Another video, Fig. 2, documenting the 7.8-magnitude earthquake in Turkey on February 7, 2023, displays flashes with less defined origins where public illumination is on during the first flash, Fig. 2a, while public illumination is off during the following flash, Fig. 2b. Both recordings were taken in residential areas, the first by a surveillance camera and the second via a mobile phone. A separate video, Fig. 1b, accessible at https://video.corriere.it/video-virali/strane-luci-apparse-cieli-marocco-prima-devastante-terremoto/fa2e4bc6-5179-11ee-929c-7dcc808a97b8, depicts six bright points moving across the desert sky. Unfortunately, details such as the times and locations of these observations are not provided by newspapers.

Fig. 1 – Two photograms of the two videos capturing unusual light phenomena of the Morocco earthquake, flashes in a and luminous points in b

Video footage capturing similar phenomena has become increasingly common in the aftermath of numerous recent earthquakes, facilitated by the widespread use of mobile phones and surveillance systems. Consequently, the term "seismic lights" is now regularly employed, surfacing multiple times each year, within a progressively expanding community of journalists and bloggers. The implications of this growing awareness present an intriguing aspect. The phenomena associated with strong earthquakes, often serving as precursors, consistently contribute to ongoing discussions. Yet, an essential gap warrants examination before delving into the implications, namely, the absence of a critical perspective in the reporting of these recordings.

Fig. 2 – Two photograms of the same video in two different moments capturing flashes of the Turkey earthquake, during the first flash in a and during a following flash in b

Indeed, a significant portion of recent filming has concentrated in inhabited areas where the population resides, coinciding with the presence of an electricity distribution network. As seismic waves traverse through, the anchoring points of the electrical grid oscillate, causing electrical cables to stretch and break at vulnerable points, Fig. 3. During the 2009 L'Aquila earthquake (Fidani, 2010), numerous accounts described electrical cables detaching from the corners of houses at the moment of the tremor, emitting sparks ranging from red to blue. Furthermore, there were discharges observed between high-voltage cables in the vicinity of the city during the earthquake, resulting in prolonged illuminations resembling lightning from a thunderstorm. Many instances of seismic lights may have originated from short circuits in the electrical grid and are not mysterious phenomena without clear explanations. Regarding bright spots in the sky, historical testimonies abound, and several videos have consistently reported them, displaying stable light characteristics with oscillating colours transitioning from red to yellow to white. In some recent cases, explanations have been offered, ranging from the mention of Chinese lanterns to attributions of the phenomenon to drone movements, and even digital artifacts intentionally created to suggest extraterrestrial visits. Regardless of the interpretation, it is crucial that when a digital document captures an unusual phenomenon, it should include essential details such as the date, time, and location of the observation.

Fig. 3 – Photo taken February 16, 2010, a man walks down an earthquake damaged street with fallen electrical lines in downtown Port-au-Prince; source: The Associated Press

On the flip side, individuals captivated by the mystery these phenomena evoke are undoubtedly inclined to seek explanations. It remains a possibility that some are driven solely by the desire to write articles that garner the highest number of reads. However, does this account for the actual absence of a critical perspective? Generally, incorporating a degree of criticism tends to enhance the appeal of an article. Could it be that our accustomed mode of communicating science, synonymous with presenting only established results, stifles critical observation? In this context, the reality of numerous imperfect endeavours, striving for limited and incremental outcomes, gets lost in communication. It seems that the role of those reporting news is reduced to merely cataloging observations as scientific findings. In this process, there is no space for questions, no allowance for error, and no opportunity for a genuine effort at understanding. Instead, there exists only the cataloging of consolidated results as the "product" of science. Yet, every result, sooner or later, will face scrutiny and potential refutation within its scientific domain. Consequently, science cannot be exclusively identified with its outcomes, and relying solely on results in communication appears to foster a lack of critical thinking.

Cloudless and thunderless lightning, along with subdued discharges of electric lights and a widespread reddening of the sky, are frequently observed hours before the occurrence of the main earthquake event. Centuries of collecting testimonies have revealed some common traits, such as their prevalence in rift zones (Thériault et al., 2014). Despite being regularly observed,

photographed, and filmed, these phenomena lack unequivocal and certain interpretations. Instead, they represent phenomena that necessitate further study to unveil their connection with earthquakes. The essence of science lies not in providing definitive interpretations but in the approach and method employed for study, encompassing hypotheses, tests, and attempts that may occasionally prove incorrect. Can seismic lights be interpreted as a signal of the impending strongest event during a seismic swarm? The answer is not without uncertainty. Even with instrumental observations, which have been feasible for some time (Fidani, 2010), and can be activated in the event of a swarm in the area of interest, uncertainties persist. While personal awareness of seismic lights can serve as a means of self-protection or safeguarding one's family (Witze, 2014), the collective utilization of this awareness necessitates the preparedness of the population to discuss such a possibility.

Finally, earthquake lights serve as a compelling topic for initiating discussions surrounding these tragic events. They engage both those who haven't directly experienced the tremor and those who have experimented with memories of deafening thuds, screams, helplessness, and pain. For the former, these lights are spectacular phenomena highlighting the immense energies unleashed, involving the atmosphere, yet underscoring the recurring nature of such tragedies. Hopefully, for those who lived through the earthquake, discussions unfold from the days before and after, gradually converging on the moment of tragedy. This approach allows individuals to revisit the traumatic experience, starting from a calmer perspective. The collection of testimonies following the earthquake in L'Aquila revealed the facilitation that this topic provides in sharing personal experiences. It's not merely a therapeutic exercise aimed at dispelling lingering fears but a valuable contribution to "save" those destined to undergo a similar experience, transforming trauma into something constructive. Conversations about lights, unique observations, and the behaviour of domestic animals hold great potential in the more serene re-enactment of the event in childrens. Recognizing that dear pets and companions have also experienced it creates a shared understanding that helps individuals discuss their emotions, potentially making the event seem less daunting.

What favors this form of communication from the typically probabilistic communication? Individuals who undergo the harrowing ordeal of an earthquake often wonder if they will face such an experience again. However, the probabilistic approach states that we don't know and that it is not possible to know. Moreover, a purely probabilistic approach concentrates exclusively on the epistemological aspects of acquiring information about future earthquakes by relying on past series of events. It overlooks the essential consideration of the earthquake's nature, its ontology. Consequently, communication based on a probabilistic approach falls short.

References

Fidani C.; 2010: The earthquake lights (EQL) of the 6 April 2009 Aquila earthquake, in Central Italy, Nat. Hazards Earth Syst. Sci., 10, 967–978.

Thériault R., St-Laurent F., Freund F. T., Derr J. S.; 2022: Prevalence of Earthquake Lights Associated with Rift Environments, Seismological Research Letters, 85 (1): 159–178.

Witze A.; 2014: Earthquake lights linked to rift zones. Nature, doi.org/10.1038/nature.2014.14455.

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E se… (What if…) a game to learn about risk perception

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The role of science and its public perception is pivotal for societal resilience, a fact underscored by the profound impact of COVID-19. How society responds to scientific findings and the trust citizens place in them is closely tied to the effectiveness of scientific communication (Reuter and Spielhofer, 2017). Consequently, it is imperative to formulate innovative strategies and protocols for communicating science and risk (Appleby-Arnold et al, 2021).

Italy, geologically one of the most complex and scientifically intriguing countries globally, faces significant seismic and volcanic hazards. Focusing on the Campania region, particularly the Phlegraean Fields, a supervolcano near Naples, the area exhibits unique geological features, including 24 craters and volcanic edifices, many submerged. The region experiences hydrothermal activity and bradyseismic phenomena, with recent reports indicating inflation around Pozzuoli and increased seismic activity.

In light of these geological challenges, public awareness and education about general and seismic risks, especially among younger generations, assume paramount importance. Recognizing the influential role of the younger demographic in societal scientific awareness, it is crucial to employ effective language and engagement strategies (Musacchio et al., 2023).

In this context, the use of Serious Games, a balance of serious and playful elements, emerges as an innovative science communication tool (Veldkamp et al., 2021). These games actively involve participants, enhancing their learning experience.

In parallel, integral to risk analysis is the use of downward counterfactual analysis, a cognitive psychology concept. While people often contemplate how situations could have been better, considering how they might have been worse is less common. In the realm of risk assessment, the downward counterfactual is a valuable tool. It prompts a deliberate examination of how events might have taken a more adverse turn, contributing to enhanced disaster preparedness and avoiding unexpected surprises.

The preparedness for risk, intertwined with the identification of danger factors and anticipation of their impacts, can be nurtured through exercises that cultivate counterfactual thinking and associated intelligences. This approach finds application in addressing extreme natural risks such as volcanic eruptions and periods of volcanic unrest.

Bagnoli, venue of the Science Fair “Futuro Remoto”, situated in the Phlegraean Fields caldera, presents a scenario where public perception of volcanic risk is low. To elevate awareness, a democratic and egalitarian role-playing game has been designed for the 2023 edition of “Futuro Remoto”, offering an interactive and instructive experience for participants.

The initiative aims to place participants at the core of the learning process, fostering not only the acquisition of scientific knowledge but also the development of problem-solving and leadership skills.

Participants engage in a roundtable of Counterfactuals in the Negative, imagining historical volcanic eruptions as having worse outcomes. This interactive exercise enhances individual risk intelligence.

Finally, an evaluation protocol has been developed to assess the impact of the experience on risk perception. This presentation focuses on presenting the outcomes of this evaluation after the 2023 edition of “Futuro Remoto”, where almost 200 participants joined the game.

Fig. 1 – Poster of the Activity at Futuro Remoto 2023

References

Appleby-Arnold, S.; Brockdorff, N., and Callus, C. (2021). Developing a “culture of disaster preparedness”: The citizens’ view, Int. J. Disaster Risk Reduct.,Vol. 56,102133,ISSN 2212-4209. doi:10.1016/j.ijdrr.2021.102133

Musacchio G, Saraò A, Falsaperla S and Scolobig A (2023), A scoping review of seismic risk communication in Europe. Front. Earth Sci. 11:1155576. doi: 10.3389/feart.2023.1155576

Reuter, C., and Spielhofer, T. (2017). Towards social resilience: A quantitative and qualitative survey on citizens' perception of social media in emergencies in Europe, Technol. Forecast. Soc. Change, Vol. 121, Pages 168-180, ISSN 0040-1625. doi: 10.1016/j.techfore.2016.07.038

Veldkamp, A., Knippels, M.C.P.J., and van Joolingen W.R. (2021). Beyond the Early Adopters: Escape Rooms in Science Education. Front. Educ. 6:622860. doi:10.3389/feduc.2021.622860

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Preparing for disasters through games: a worth taking bet?

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The risk education represents a significant factor in improving the awareness and knowledge required to reduce the impact of earthquakes on the territories (UN, 2015). For this reason, the Institute of Environmental Geology and Geoengineering of the National Research Council has established an educational laboratory aimed at helping students understanding the concept of seismic risk and disseminating knowledge about mitigation measures to reduce the impact of disasters (Gaudiosi et al. 2022). The chosen target was also calibrated in light of the young people's renewed interest in new technologies and different editorial forms (comics and graphic novels).
The laboratory hopes to transmit methods for sismic microzonation and earthquakeresistent city planning (Benigni et al. 2022), through tabletop games and three-dimensional representations of the territory (Gaudiosi et al. 2023). The direct and shared participation in laboratory activities, combined with game experience (Filomena et al. 2023), promotes understanding of the physical phenomenon of the earthquake, its consequences and effects, and the discussion of one's own prejudices.
The measurement of acquired awareness is carried out using appropriate questionnaires.
Finally, the goal of this contribution is to establish a cross-institutional network in which the authors participate in order to disseminate and confront proposals for integrated risk communication methods throughout the scientific community.

References

Benigni M. S., Fontana C., Giuffrè M., Tomassoni V.; 2022. L'analisi della Condizione Limite per l'Emergenza a dieci anni dalla sua istituzione: limiti attuali e potenzialità future, Urbanistica informazioni. ISSN: 2239-4222

Filomena M. G., Pace B., De Acetis M., Aquino A., Crescimbene M., Pace M., & Alparone F. R.; 2023. Play to Learn: A Game to Improve Seismic-Risk Perception. Sustainability, 15 (5), 1-11.

Gaudiosi I. et al.; 2022. From the Institute of Environmental Geology and Geoengineering of the National Research Council (CNR IGAG) to schools: introducing cultural heritage into classrooms to foster awareness about natural risk prevention. Rendiconti Online della Società Geologica Italiana. DOI: 10.3301/ROL.2022.14;

Gaudiosi I., Mancini M., Caielli G., de Franco R., Moscatelli M., Stigliano F.; 2023. Microzonazione sismica: quali scenari per il futuro? Geologicamente, 10. ISSN: 2705-0149 https://doi.org/10.3301/GM.2023.01

UN – United Nations; 2015. Sendai Framework for Disaster Risk Reduction 2015-2030. https://www.preventionweb.net/files/43291_sendaiframeworkfordrren.pdf

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From risk to safety for a resilient governance

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Background and motivations. Events and phenomena with a strong impact on the territory are increasingly common and are exacerbated by climate change (UNDRR, 2015). They include natural hazards (e.g., floods, tornadoes, earthquakes, hydrogeological instability phenomena), as well as human activities (e.g., air pollution, water pollution, deforestation, soil degradation) or combinations of both. These events occur with greater frequency and intensity, affecting all countries around the world.

The interactions between natural and human systems further complicate risks. Infrastructure development in hazardous zones, such as coastal areas prone to hurricanes or earthquake-prone regions, elevates exposure to natural disasters, increasing the potential for widespread damage and disruption. Simultaneously, degraded ecosystems, such as deforested lands or polluted water sources, diminish their natural buffering capacity, leaving communities more vulnerable to the adverse impacts of environmental changes.

The complex interplay between natural and human systems underscores the importance of holistic approaches to risk management, necessitating strategies that consider both environmental and societal factors to build resilient and sustainable communities. At the same time, social and economic networks have become deeply interconnected locally and globally. Disruptions to any part of complex, cross-border systems can trigger widespread cascading impacts difficult to predict and manage. Interdependencies between infrastructure, supply and value chains mean disturbances are more system-wide with the potential for massive harm.

These multifaceted issues demand holistic, intersectoral approaches respectful of territorial specificities. While climate adaptation and disaster risk reduction are priorities, siloed actions are insufficient. Cooperation across governments, private stakeholders, scientists and communities is necessary to understand dynamic risk contexts and cocreate adaptive solutions. In this process, an effective communication plays a strategic role.

Recognizing the scale and urgency of these sustainable development challenges, the UN's 2030 Agenda (United Nations General Assembly, 2015) aims to build resilience through policy and financing coherence, ecosystem protection, social inclusion, innovation and preparedness. Yet integration of risk knowledge and management into strategies, planning and decision-making remains fragmented.

The COVID-19 crisis further underscored gaps, particularly regarding coordination of emergency responses, continuity of critical services and support for vulnerable populations. It revealed deficiencies in integration and social protection requiring attention in recovery agendas. The EU's "Next Generation EU" recovery plan (European Union, 2023) and related framework emphasize building back in a manner that is greener, fairer, and more resilient against future adversities.

To achieve disaster risk reduction, as indicated by the Sendai Framework (UNDRR, 2015), it will be imperative to reduce hazards and vulnerabilities through coordinated territorial action. International cooperation on evidence-based risk assessment, management of cross-border risks, knowledge exchange and capacity building should be scaled up. Strong multilevel governance and

cooperation between countries are needed to align risk reduction with sustainable development trajectories and ensure balanced, resilient pathways ahead.

Dealing with the complex interconnected challenges of risk, climate change and development requires approaches that embrace uncertainty and evolve over time. Systems thinking acknowledges the high degree of unpredictability from emergent, nonlinear dynamics between interacting social, ecological, technological and infrastructure components. Events often occur in unforeseen ways and new risks can materialize that previous risk assessments did not anticipate. Continuous learning and adaptations are necessary to incorporate evolving understandings of complexity into flexible management strategies. Surprises are inevitable, so building in redundancy, modular solutions and feedback loops helps sustainable development pathways absorb disruption. Cross-disciplinary integration of perspectives from social, natural and engineering sciences also aids accounting for unknown unknowns (Grimaz et al., 2024). Scenario methodologies and adaptive governance enable recalibration of policies and projects to surprise outcomes within an overall risk-informed strategic direction. Such innovation and preparedness help promote resilient pathways despite a substantial immeasurable component of risks in complex, evolving systems.

In addition, the UNDRR Global Assessment Report 2022 (UNDRR, 2022) recognizes that achieving transformative change to build disaster and climate resilience requires transforming governance systems. Traditional top-down, rigid governance approaches are inadequate to address complex, interconnected risk in a volatile world. The report advocates for more flexible, inclusive and collaborative modes of governance termed "transforming governance". The report emphasizes the need for transforming governance, taking into account aspects of systemic risk, uncertainty and the needs to take actions in order to build resilience and achieve the UN sustainable Development Goals.

Discussing on the key aspects highlighted by the UN Agenda 2023, the Sendai Framework and the Global Assessment Report 2022, the researchers of the Safety and Protection Intersectoral Laboratory (SPRINT-Lab) of the Polytechnic Department of Engineering and Architecture at the University of Udine, also UNESCO Chair on Intersectoral Safety for Disaster Risk Reduction and Resilience, started an interdisciplinary process of discussions to work across silos and face the issues related to the resilience to disasters for a sustainable development. In detail, this paper aims to rise attention on the need to improve communication for transforming governance, considering the disaster prevention, preparedness, response, and recovery, in order to pass from an approach focused mainly on the risk assessment to a risk-informed approach finalized to reach safety.

Governance as “play the game”. In the Global Assessment Report 2022, the transition to systemic risk governance is presented through the metaphor of “playing the game” (North, 2008; Shepsle, 2012). In this report, the metaphor of "playing the game" is employed to denote the systems, arrangements, structures, strategies, and processes involved in agreeing upon and formulating rules, laws, and policies, as well as making and implementing collective decisions. These elements are not rigid and can vary. Effective governance models have the ability to adapt, facilitating prompt responses to crises and monitoring gradual changes, allowing for the implementation of longer-term measures (IRGC, 2018; UNDRR, 2022).

Overall, transforming governance through collaborative, multi-level "game playing" is key to adaptively governing complex, multicausal and evolving disaster and climate risks.

Traditionally, governance has followed a top-down, segmented approach to addressing societal challenges like risk. Problems are understood through the narrow lens of separate government

ministries and agencies. Decisions are made by political officials with limited stakeholder input. Actions are implemented according to rigid plans with few feedback loops to course correct.
However, the COVID-19 pandemic and climate change have proved the limitations of such linear, siloed governance in our modern, complex world. Risks emerge from dynamic interactions across many interconnected human and natural systems, defying segmentation. Uncertainty and emergent, non-linear behaviours demand continual learning and adaptation not allowed for in rigid structures. Vulnerable communities fall through cracks without grassroots collaboration.
Crucially, "playing the game" fosters adaptive processes wherein actions are continuously calibrated alongside monitoring and feedback. Plans evolve in tandem with changes in conditions on the context or new insights. Responses fill emergent needs through grassroots action complementing strategy. Governance demonstrates agility unseen in rigid, compartmental approaches.
Governance is a multifaceted process that involves understanding complex problems, making informed decisions, and implementing actions to achieve specific goals (Fig. 1). In today's intricate and uncertain world, marked by systemic risks, this process becomes even more crucial. Effective governance demands a dynamic and adaptive approach, recognizing the interconnections and uncertainties inherent in our complex global landscape.

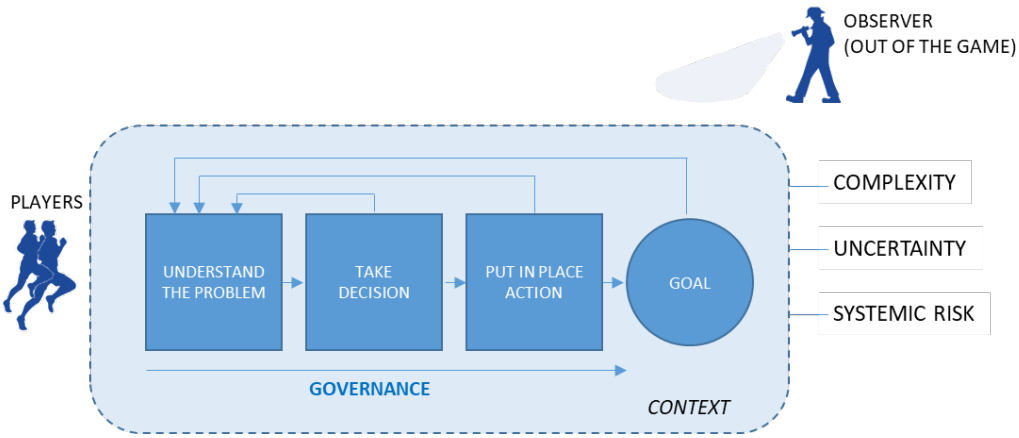

Fig. 1 - Non-linear governance process in a changing context: different perspectives of the different subject.

An essential passage in governance is gaining a deep understanding of the problem at hand. In our modern world, issues are rarely isolated; instead, they are embedded in a web of interconnected factors. This complexity requires a nuanced understanding of the root causes, potential impacts, and the broader context in which the problem exists.
The governance process requires making decisions that are both strategic and contextually relevant. Decisions must be informed by a comprehensive understanding of the complexity, considering the diverse and often interdependent factors that contribute to the issue. The decision-making process should be agile, allowing for adjustments based on emerging information and changing circumstances.
Putting in place actions is the means for passing from decision to goal attainment. Actions must be carefully crafted to address the specific facets of the problem. This requires a proactive stance, adapting to unforeseen challenges and leveraging opportunities as they arise.
In the dynamic landscape of contemporary governance, each passage — understanding, decision-making, and implementation — demands a continuous feedback loop. Regular assessments and evaluations ensure that strategies remain effective and adaptable. Feedback mechanisms provide

insights into the evolving nature of the problem, enabling governance structures to evolve in tandem.

In this framework, governance unfolds through two distinct perspectives:

- the actively engaged players, i.e. those called to endeavour for reaching the goal. Players, whether individuals, organizations, or governments, navigate the complexities firsthand, making decisions and implementing actions.
- the observers who analyse, critique, and learn from the process, checking the outcomes and verifying the respect of the rules of the game. Observers contribute by providing critical assessments, learning from outcomes, and offering insights that can inform future governance endeavours.

Just as games require collaboration between diverse players operating within flexible yet coherent rules, risk governance too requires opening up decision-making arenas. By "playing the game", problems can be understood more holistically by incorporating local risk knowledges alongside technical expertise. Participatory platforms allow stakeholders to jointly frame issues, trade-offs and solution space, building ownership over top-down plans. In short, "governing as playing the game" offers a promising metaphor for the flexible, inclusive, adaptive forms of multi-stakeholder participation with multiple perspectives, and joint problem-solving demanded by today's complex risk governance challenges.

The governance process has to be applied in the four phases of the Disaster Risk Management Cycle (UNDRR) (Fig. 2), adapting goals and strategies to the current context.

The view in Fig. 1 permits to emphasise also the importance of communication both among all the passages of the governance process and among involved subjects.

In particular, it is important to pass knowledge from those called to understand the problem, those called to take decisions and those called to implement actions. The endeavours and activities in each passage strongly rely on the comprehension of the main requirements and specificities of the other passages, and this aspect can be achieved only through a proper communication (bridge).

For example, understanding the problem requires knowing which is the goal of the governance, which are the requirements of decision-makers and which could be possible and feasible actions to reach the goal. Without this entire knowledge, every understanding would remain an end in itself, potentially compromising attempts to make decisions and implement actions in the context. A proper communication approach, that is aware of the requirements of all the other passages and of the context in which it is developed is an essential aspect to transform governance.

Resilience. The Disaster Risk Management Cycle (DRMC) conceptualization (Fig. 2) forms the basis for the disaster preparedness policies established by the United Nations in recent decades (Ahmad Basri et al., 2022). In the DRMC resilience can be interpreted as the ability to reach a condition of “normality” (or “new normality”) as quickly as possible; this means the ability to close the loop of the post-event phases (response and recovery) in a fast and effective way. This capacity is closely related to what has been done and invested before the event, i.e., in the prevision-prevention and preparation phases, and to what has been capitalized from positive and negative experiences in previous events.

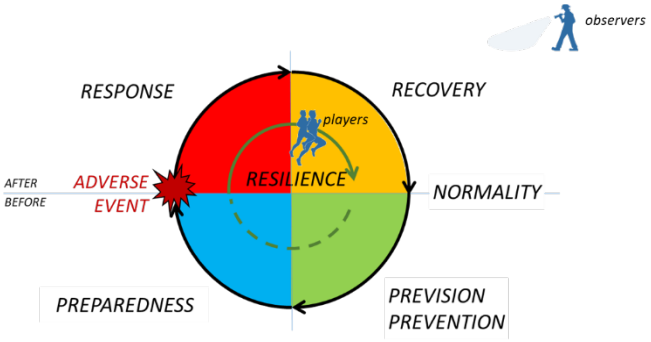

Fig. 2 - The Disaster Risk Management Cycle and the resilience: different points of view of the subjects

It's worth noting that an effective and good recovery should result in a new normality at a level better than the pre-event, introducing elements of improvement and regeneration compared to the pre-event state. To improve resilience, the system uses not only its ability to respond and recover, but also its ability to anticipate, regenerate and learn. These capabilities are particularly important given that adverse events may recur over time and the system has the ability to prepare in advance for future events. The ability to learn from the gained knowledge gives the system a potential evolutionary capacity. An ecological-evolutionary approach involves assuming the role of the active agent, i.e., as the player, whether as an individual, a group, or a community. In this perspective, the system's resilience is contingent upon the capabilities of these players, including their knowledge, strategies, and tools used to comprehend the issue, make decisions, and implement actions. The correctness, relevance, timeliness, contextualization, and effectiveness of these actions (or inactions) collectively determine the system's resilience.
Moreover, there are external observers, who have a comprehensive overview of the entire situation. They analyse the outcomes resulting from the actions of the players, considering the entire process, or even during the development of each step, as well as the appropriateness, effectiveness, and efficacy of the entire process. However, these observations are conducted with an ex-post point of view or ex-ante (but out of the game). External observers possess knowledge of how the system evolved under the specific circumstances and on which have been the results of the actions. In this case, the task of the observer is to interpret the situation to gather knowledge and experience that can be applied to future events.
In dealing with complex systems where continuous environmental changes occur, the focus shifts to navigation, requiring monitoring, anticipation, adaptation, and learning. Safety management in today's complex world must consider numerous risks, dimensions, and disciplines, accounting for the open and unpredictable nature of the system.
In response to these challenges, the player’s perspective becomes pivotal in determining the right actions at the right time, especially in the face of unpredictable events. The intersectoral approach strives to link technical aspects with socio-economic and human behaviour, fostering interdisciplinary and inter-institutional synergies to enhance contextualization, finalization, and resilience in safety management.

From risk to safety. Effective disaster risk reduction (DRR) is a critical component of ensuring the safety and resilience of communities and nations. The journey from risk to safety involves a comprehensive shift in governance strategies, acknowledging the dynamic nature of hazards and emphasizing proactive measures and the need of a constant contextualization. Disaster risks are complex and ever-evolving, influenced by factors such as climate change, urbanization, and socio-economic conditions. Approaching DRR solely through risk management is akin to playing catch-up

with an unpredictable adversary. As hazards become more intricate, the need for a paradigm shift becomes evident.

Transitioning from risk to safety involves a shift from reactive measures to proactive, preventive actions. Instead of primarily focusing on responding to disasters, safety-oriented governance aims to prevent or minimize their impacts through strategic planning, investment in resilient infrastructure, and community empowerment.

Safety-focused governance demands an integrated and inclusive approach. Governments, communities, and stakeholders must collaborate to develop and implement policies that consider the multi-dimensional aspects of disaster risk. This entails breaking down silos and fostering coordination among various sectors such as health, education, infrastructure, and environment.

Shifting the focus from managing risks to enhancing safety requires passing to action, through substantial investments and endeavours in resilient infrastructure, early warning systems, and capacity-building programs. Allocating resources strategically based on vulnerability assessments is crucial for long-term safety, however any endeavour relies on a combination of strategic planning, skilled execution, adaptability, effective governance, stakeholder engagement, monitoring and evaluation, risk management, ethical considerations, and a commitment to continuous improvement.

The transition from risk to safety is a fundamental shift in mindset and strategy, requiring a holistic and forward-looking approach to disaster risk reduction. Governments must lead this transformation by adopting integrated and inclusive governance, investing in resilience, empowering communities, and crafting adaptive policies. Embracing safety as a core principle ensures that nations are not merely reactive to threats but are actively working towards creating a safer, more resilient future for all.

Conclusion. Governance in our complex and uncertain world is a dynamic process that requires a holistic understanding, strategic decision-making, and a contextualized and adaptive implementation. Systemic risks add layers of complexity, emphasizing the need for continuous feedback loops to navigate challenges effectively. The dual perspectives of players and observers contribute to a comprehensive and evolving approach to governance, fostering resilience and sustainable solutions in an ever-changing global landscape. The governance framework emphasises the importance of knowledge transfer between passages, especially the one between science and decision-makers. New challenges are open for defining and implementing effective communication for resilient governance.

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References

Ahmad Basri, S. A., Syed Zakaria, S. A., A.Majid, T., & Yusop, Z. (2022). Exploring awareness and application of disaster risk management cycle (DRMC) from stakeholder's perspective.

International Journal of Disaster Resilience in the Built Environment, 13(4). https://doi.org/10.1108/IJDRBE-09-2020-0105

European Union. (2023). Next Generation EU. https://next-generation-eu.europa.eu/index_en

Grimaz, S., De Toni, A. F., Malisan, P., Torres, J., Aristei, A., & Maiolo, A. (2024). 8. Safety and resilience for navigating towards sustainable development in the age of complexity. In F. Bucci, A. Colonna, E. Fioretto, & N. Lombardini (Eds.), KNOWLEDGE DISSEMINATION FOR THE SUSTAINABLE DEVELOPMENT (pp. 114–127). Springer Nature.

IRGC. (2018). Guidelines for the Governance of Systemic Risks. In Guidelines for the Governance of Systemic Risks. Lausanne: International Risk Governance Center (IRGC).

North, D. C. (2008). Institutions and the Performance of Economies over Time. In Handbook of New Institutional Economics. https://doi.org/10.1007/978-3-540-69305-5_2

Shepsle, K. A. (2012). The rules of the game: What rules? Which game? In Institutions, Property Rights, and Economic Growth: The Legacy of Douglass North. https://doi.org/10.1017/CBO9781107300361.006

UNDRR. (2015). *Sendai Framework for Disaster Risk Reduction*. http://www.unisdr.org/we/coordinate/sendai-framework

UNDRR. (2022). *Global Assessment Report on Disaster Risk Reduction 2022 (GAR2022)*. https://www.undrr.org/gar2022-our-world-risk

United Nations General Assembly. (2015). Transforming our world: The 2030 agenda for sustainable development. *Https://Sustainabledevelopment.Un.Org/Content/Documents/7891Transforming%20Our%20World. Pdf*, *1*, 35. https://doi.org/10.1007/s13398-014-0173-7.2

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Tsunami risk perception of the touristic population of Stromboli Island: towards effective risk communication strategies

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Abstract

Stromboli volcanic island has experienced six mass-flow induced tsunamis since 1916, accounting for more than a third of the tsunamis recorded in the Aeolian Islands in international catalogs (Maramai et al., 2019). Among these, the 2002 tsunami triggered by a collapse on the Sciara del Fuoco highlighted the need for effective risk mitigation measures, prompting universities' and research centers' efforts for volcanic and tidal monitoring of the island. Beyond probabilistic modeling of tsunamis and warning systems, effective disaster response relies significantly on studies of tsunami risk perception to improve communication and preparedness of communities most exposed to tsunami risk. Among these, transient populations such as tourists hold particular significance in risk perception studies, as their needs intersect with those of the local population, necessitating considerations in planning risk mitigation measures. As tourism attracted by the volcano is the primary revenue source for the island's community, steps are to be taken to ensure the industry's sustainability over time and prevent collapses due to exogenous shocks (Orchiston, 2011).

Methodology

As part of the B2 Stromboli Project (DPC-INGV Agreement 2022-2023), a specific research task was funded to investigate the fundamental knowledge of tourists and the resident population to develop solid risk communication strategies. A multilingual survey (n = 699) was conducted between July and September 2023 to assess tourists' risk perception and preparedness. A web-based survey instrument was chosen to allow respondents flexibility in completing the survey, and both sampling and selection errors must be considered when interpreting the data. (Moreschini et al. submitted)

Indicators of tsunami risk perception were developed to gather respondent perception of concepts derived from studies on probabilistic assessment of tsunami hazard (Basili et al., 2018) and quantitative assessment of risk (Cadorna et al., 2012) helping the identification of areas for risk communication intervention, in terms of both target and content.

Results

Results indicate that tourists correctly recognize Stromboli as subject to a relatively higher probability of being hit by a tsunami than most of the Mediterranean Sea but underestimate the overall hazard to which they are exposed.

Tourists' representations often mischaracterize tsunamis, overlooking safety threats posed by smaller events and revealing deficiencies in current communication approaches.

The data gathered allowed the development of a conceptual typology based on tourists' exposition to information on risk-related behaviors and shows how more than half of the tourists lack any information on the behaviors to follow in case of emergency. The typology was used to identify variables that influence the probability of being adequately informed by means of logistic regressions.

Given the practices within the tourism industry on the island, effective communication strategies for tourists should prioritize providing comprehensive information within the initial 24 hours of their arrival. Moreover, given the high percentage of tourists visiting the island for a few hours and within specific time slots, we encourage the authorities to provide this information before they land.

Communication strategies to achieve adequate awareness levels rely on residents' and industry operators' acceptance of new roles and on the integration of their actions with opportunities provided by communication technologies, to expand the reach and ensure the sustainability of a continuous act of communication.

References

Basili, R., Brizuela, B., Herrero, A., Iqbal, et al. (2018) NEAM Tsunami Hazard Model 2018 (NEAMTHM18): online data of the Probabilistic Tsunami Hazard Model for the NEAM Region from the TSUMAPS-NEAM project. Istituto Nazionale di Geofisica e Vulcanologia (INGV); https://doi.org/10.13127/tsunami/neamthm18

Cardona, O.D., M.K. van Aalst, J. Birkmann, M. Fordham, G. McGregor, R. Perez, R.S. Pulwarty, E.L.F. Schipper, B.T. Sinh, H. Decamps, M. Keim, I. Davis, K.L. Ebi, A. Lavell, R. Mechler, M. Pelling, J. Pohl, A. Oliver-Smith, F. Thomalla (2012). Determinants of risk: Exposure and vulnerability. Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation [Field, C.B., V. Barros, T.F. Stocker, D. Qin, D.J. Dokken, K.L. Ebi, M.D. Mastrandrea, K.J. Mach, G.-K. Plattner, S.K. Allen, M. Tignor, and P.M. Midgley (eds.)]. A Special Report of Working Groups I and II of the Intergovernmental Panel on Climate Change (IPCC). Cambridge University Press, Cambridge, UK, and New York, NY, USA, pp. 65-10

Maramai A., Graziani L., and Brizuela B. (2019). Euro-Mediterranean Tsunami Catalogue (EMTC), version 2.0. Istituto Nazionale di Geofisica e Vulcanologia (INGV). https://doi.org/10.13127/tsunami/emtc.2.0

Moreschini I., Cugliari L., Cerbara L., La Longa F., Crescibmene M., Amato A. (submitted) Stromboli Risk perception of the Touristic Population of Stromboli Island: towards effective risk communication strategies.

Orchiston C. (2011) Seismic risk scenario planning and sustainable tourism management: Christchurch and the Alpine Fault zone, South Island, New Zealand, Journal of Sustainable Tourism, 20:1, 59-79, DOI: 10.1080/09669582.2011.617827

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Risk education and communication: the experience of serious games and *Situated Learning Episodes (ELS)* in Pandemic

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Natural risk education is an essential component for disaster risk prevention: school education is crucial in the enhancement of knowledge and in risk awareness, to trigger changes towards rights choices for the Society as a whole.

The researchers of the Istituto Nazionale di Geofisica e Vulcanologia (INGV) activities devoted to schools bring students closer to the world of Research, focussing on earthquakes, tsunamis, floods issues in a non-formal context. The main aim is to train future proactive and resilient citizens, encouraging the personal development of the contents discussed with the experts, by using *trasformational learning* activities through digital games and *Episodes of Situated Learning (ESL)* (Rivoltella, 2013a).

During the COVID19 Pandemic, we have experienced, by remote learning, different *active learning* methods to enhance *behavioral change* in order to ease the automation of best practices of Civil Protection.

Dealing inductively with concepts of hazard and risk, a set of digital scientific games, participative escape rooms and *ESL*s have been designed, involving more than 10,000 students from Primary, Middle and High schools in the last four years. The answers of both teachers and students to the satisfaction questionnaires submitted at the end of each scientific special event, showed that these experimentations have turned out to be tools of school-based civic education.

During online scientific special venues, such as the European Researchers' Nights 2020-2023, the World Water Day 2021, the World Earth Day 2021, the Rome Science Festival 2021, the 10th anniversary of the 2011 Ligurian floods and the World Environment Day 2022, World Environment Day 2022, EPALE EDU HACK 2022 competition, and Fosforo Science Festival of Senigallia (MC) 2023, different activities were implemented. In particular, our didactic multihazard serious games concerning earthquakes, tsunami, flood and climate change, were used to explain natural phenomena and to communicate science. Salvina's *adventures* have been created: a young girl faces several hazardous situations, from earthquake to flood, to environmental issues. She is the protagonist of four educational quizzes: *"Salvina and the earthquake: what will she do?", "Salvina and the flood: what will she do?", "Salvina and the environment: what will she do?" and "Salvina and the 4Rs: what* will she do?" and of the online Escape Room "Let's free Salvina!" to elude natural risks. A second Escape, *"4S: Salvina and Samanta Save the Species"*, dealing with environmental issues to promote sustainable behavior, was designed in a participatory approach

with a second class of Middle school supported by teachers and INGV researchers. Each game was played as a challenge that had to be overcome to advance in the game as the result of *cooperative learning* by the whole class in the competition. These gaming competitions are all designed on *inquiry-based learning* and have been enthusiastically played simultaneously by students from all over Italy (Piangiamore & Maramai, 2022).

In the reduction of natural hazards, knowledge of the past plays a key role. This is why, experimenting with a new didactic model experienced and based on the *ESL* at school, we decided to focus the activity on the study of past earthquakes and tsunamis for facing the future with greater awareness.

ESL suggests an innovative way of studying with the use of new technologies, as a new way for teaching and learning based on a flipped-up approach. This activity facilitates the development of all key competences and citizenship skills, stimulating discussion among peers and with adults and fostering critical thinking development (Rivoltella, 2013b; Piangiamore et al., 2016).

In particular, two *ESL* project addressed to High schools have been realized: *"Earthquakes: history teaches us the future: researchers for a day with experimentation in didactics for ESL"* and *"Tsunamis: history teaches us the future researchers for a day with experimentation in didactics for ESL"*. In both activities students design a final digital communication product developing life skills, focusing on historical seismic studies of both past earthquakes and tsunamis. The experiences triggered students' interest, favoring learning at a distance in a context that challenges knowledge, skills, attitudes and competences. On the other hand, teachers can evaluate all the three phases of *ESL* activity to reach a formative assessment (Rivoltella, 2014).

The above-mentioned experiences underlined that risk education and best practices of natural risk reduction can be instilled automatically to promote safe behaviors to be implemented during natural events, building a *lifelong-lifewide* resilience (Piangiamore et al., 2021).

References

Piangiamore, G.L.; Maramai, A. Gaming and Resilience: Teaching by Playing Together—Online Educational Competition at School during the Pandemic. Appl. Sci. 2022, 12, 11931. https://doi.org/10.3390/app122311931

Rivoltella, P.C. Fare didattica con gli EAS - (Episodi di Apprendimento situato); La Scuola Ed.; Brescia, IT, 2013a.

Rivoltella, P.C. L'agire didattico. Manuale per l'insegnante; La Scuola Ed.; Brescia, IT, 2013b.

Rivoltella, P.C. Episodes of Situated Learning. A New Way to Teaching and Learning. Research on Education and Media, 2014, VI, N. 2, 79-87.

Piangiamore, G.L.; Musacchio, G.; Devecchi, M. Episodes of Situated Learning: natural hazards active learning in a smart school. In Interactive Learning: Strategies, Technologies and Effectiveness; Lewis M. Hunt Eds.; Nova Science Publisher: New York, USA, 2016; ISBN 978-1-63484-198-6.

Piangiamore, G.L.; Falsaperla, S.; Eva, E.; Musacchio, G. Seismic risk communication: Let's students show their own way. Ann. Geophys. 2021, 64, 1–16.

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Real-time seismicity on your smartphone

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The INGVterremoti mobile application for smartphones and tablets is a tool designed to provide real-time earthquake information and updates on seismic activity in Italy and around the world. Developed by the Terremoti Department of the Istituto Nazionale di Geofisica e Vulcanologia (INGV), this App offers a user-friendly interface combined with powerful features to stay informed about seismic events and earthquake research and monitoring activities.

Since March 10, 2011 (one day before the 2011 Tohoku earthquake), the INGVterremoti App for iOS has been distributed in the App Store. It was the first seismological App released by a scientific institution. The goal was to provide fast communication about seismic information tailored to users with mobile devices, an audience that was beginning to be dominant. This first version of the App showed data on the most recent earthquakes on Italian territory and the strongest events in the rest of the world. In addition through the "Search" section it allowed the visualisation of Italian seismicity from 2005 onward.

Already from the first version, special attention was also paid to scientific information about earthquakes by directly linking to the contents, pages and articles, of the blog-magazine INGVterremoti.com. This included educational and popular content to improve users' understanding of seismic activity, explanations of the science behind earthquakes, how to prepare for and behave in case of an earthquake event. This educational component made the app useful not only during emergencies but also as a learning resource.

When the App was first released, the smartphone and tablet app market was in its infancy, at least in Italy. Therefore, because of the novelty and effectiveness of a product released by a well-known scientific institution, during the earthquake crises from March 2011 to July 2013 the INGVterremoti App was repeatedly ranked in the top 10 positions among the most downloaded Apps in the Apple Store (Italy).

Over the years this App has been constantly updated (with 3 major releases) both due to the evolution of the technological platforms in which it operates and due to changes in the INGV seismicity information service of which they are an integral part. In 2011, the main innovation was the ability to consult the entire INGV Italian seismic catalogue since 2005 by downloading it directly to the device during installation to allow the App to work without a data connection (e.g., in remote areas or during an earthquake emergency). The improvement of mobile data coverage in Italy and the creation of APIs to programmatically access the INGV earthquake database allowed in

2016 the release of a completely new version of the INGVterremoti App, finally distributed not only for iOS but also for Android. Among the main new features is the ability to consult seismicity since 1985.

In 2022, the iOS version (and in the following months also the Android version) was completely rewritten and deeply renewed in graphics and released in the Stores. The user interface was changed to a cleaner and more intuitive design, making it accessible to users of all levels of technological expertise. The interface prioritises ease of navigation, ensuring that users can quickly access the information they need during critical moments.

Changes have also been made on the map interface that displays earthquake data in a simpler way in terms of symbology and interaction. Users can explore recent earthquake events, view their location on the map, and access detailed information about each earthquake on the information pages of the portal http://terremoti.ingv.it.

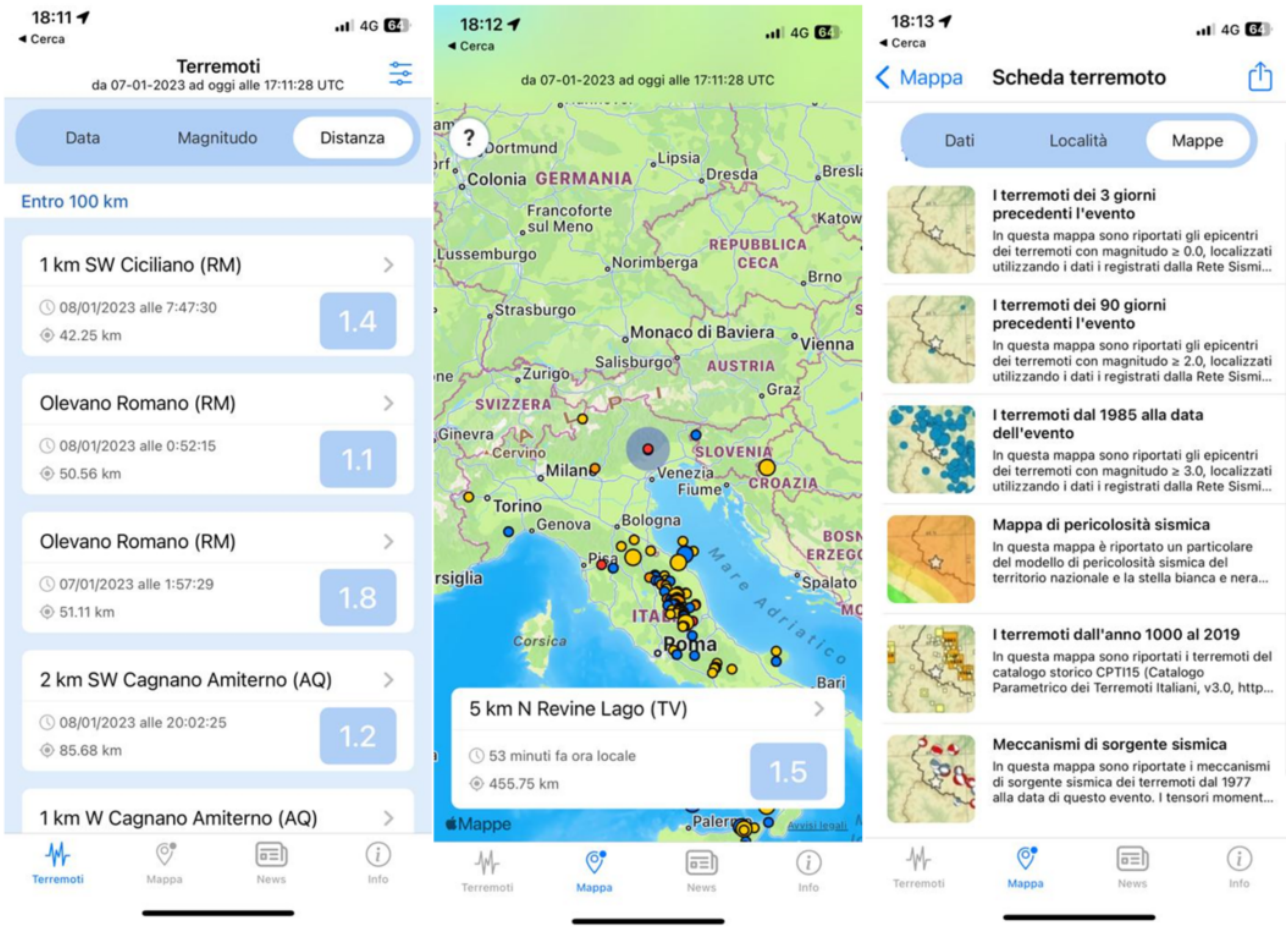

Fig. 1 – The user interface of the latest version of the INGVterremoti App. The figure shows the list of the latest earthquake events, the corresponding map, and a sample of the information available for each earthquake.

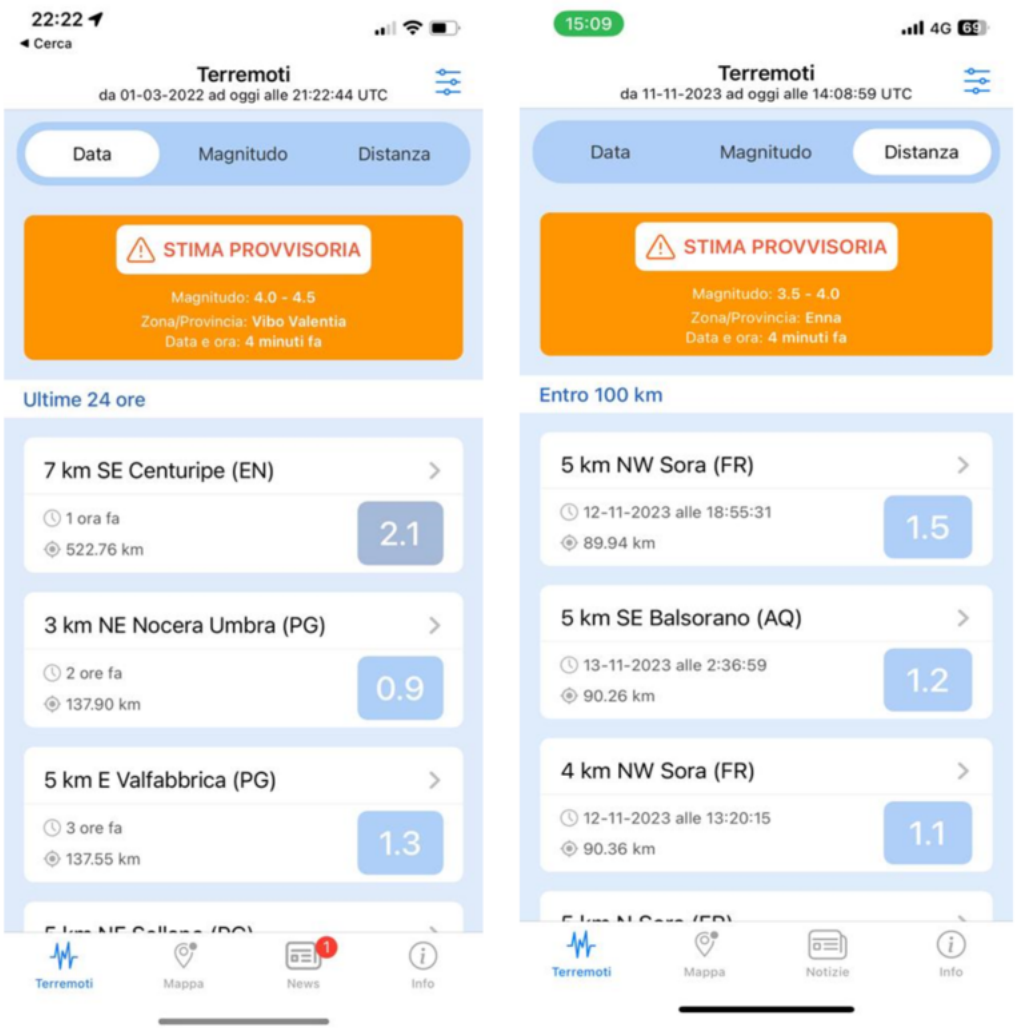

Fig. 2 – Two examples of the "provisional estimate" message displayed in the list of latest earthquakes in the App interface.

Fig. 3 – A card posted on INGVterremoti social media to launch the latest version of the App. It also features QR codes to download the two versions for IOS and Android.

The most important change in recent years is the publication of automatic localizations (provisional estimate) for events of magnitude greater than 3 occurring over the national territory, including coastal and border areas. Only events that have good localization parameters are published to avoid false events and Italian volcanic areas are excluded, for the moment.

The message of the provisional estimate reports the same information already published since 2018 on the Twitter channel @INGVterremoti and on the portal http://terremoti.ingv.it: the time of the event, a magnitude interval, the epicentral zone.

In recent months, work is being done to include in the next version of the App a push notification service that is highly requested by users. The service is currently in an advanced testing phase and will provide early warnings about major earthquakes, ensuring that users receive instant notifications about seismic activity in their region. The notification system will be customizable and will allow users to set parameters based on magnitude and proximity to their location, ensuring personalised and relevant updates.

References

Comunello, F., Polidoro, P., Lauciani, V., Mulargia, S., and Casarotti, E. (2015). “No misunderstandings during earthquakes: Elaborating and testing a standardized tweet structure for automatic earthquake detection information,” in ISCRAM 2015 Conference Proceedings 12th International Conference on Information Systems for Crisis Response and Management, (Kristiansand, Norway University of Agder (UiA)). Editors M. Büscher, T. Comes, and A. Hughes 7, 2411–3387.

Pignone, M., Nostro, C., Amato, A., Casarotti, E., and Piromallo, C. (2012). The INGVterremoti blog: A new communication tool to improve earthquake information during the Po Plain Seismic sequence. Ann. Geophys. 55, 42. doi:10.4401/ag-6179

Pignone M, Amato A, Nostro C, Casarotti E, Meletti C, Quintiliani M and Lauciani V (2022), Public earthquake communication in Italy through a multisource social media platform: The INGVterremoti experience (2010–2022). Front. Earth Sci. 10:1003867. doi: 10.3389/feart.2022.1003867

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Trust in authorities and experts as shaping factor of risk perception

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In September 2019, the United Nations Secretary-General, António Guterres, remarked that our global community is experiencing a significant challenge known as 'Trust Deficit Disorder'. He noted a decline in people's trust in political institutions, a growing polarization, and the increasing prevalence of populism.

The decline in trust among European and non-European citizens is spanning various institutional levels and is a concerning aspect of the turbulent times experienced in Europe and beyond.

In such a context, trust plays a pivotal role in all facets of disaster resilience, encompassing the relationships between citizens and institutions, citizens and experts, policymakers and experts, and among different governance levels. Risk perception arise from an intricate interplay involving individuals, communities, institutions, and experts.

The H2020 CORE (sCience and human factOr for Resilient sociEty) project conducted a survey whose main scope is to understand the role of trust in scientific experts (virologists, geoscientists, biologists, and experts in general in the disaster resilience field) in determining citizens' risk perception. The tool is also targeted to disseminate proposed strategies to policymakers and practitioners useful to increase social acceptance of emergency procedures and risk mitigation actions. The CORE questionnaire was developed using the SurveyMonkey tool and was designed to explore the connection between trust in authorities and experts and risk perception, specifically concerning various risks such as earthquakes, tsunamis, pandemics, flash floods, industrial accidents, wildfires, and terrorist attacks. It was available in multiple languages, including Italian, English, French, German, Hebrew, and Tagalog.

The survey questions were catalogued in three different blocks, i.e. *trust in Authorities and experts*, *risk perception*, and *disasters' preparedness*. A fourth block of questions, useful to stratify the sample, concerns *socio economic and demographic characteristics*.

Based on the existing literature in the investigated topics, we expect that data analysis will reveal the significance of trust in institutions, including government authorities, the national health system, enforcement authorities, rescue authorities, and NGOs, as well as scientific experts. Thus, it should highlight the central role of trust in shaping risk perception. The ultimate goal of the research is to promote the development of a two-way trust: from citizens to institutions, from experts to citizens, and vice versa. This aims to establish a collaborative framework for effective action in reducing and preparing for disaster risks, and fostering the behavioral change.

References

Algan, Y., Cohen, D., Davoine, E., Foucault, M., & Stantcheva, S. (2021) - Trust in scientists in times of pandemic: Panel evidence from 12 countries. Proceedings of the National Academy of Sciences, 118(40), e2108576118, https://doi.org/10.1073/pnas.2108576118.

Bronfman, N. C., Cisternas, P. C., López-Vázquez, E., & Cifuentes, L. A. (2016) - Trust and risk perception of natural hazards: implications for risk preparedness in Chile. Natural hazards, 81, 307-327, https://doi.org/10.1007/s11069-015-2080-410.1007/s11069-015-2080-4

Wachinger, G., Renn, O., Begg, C., & Kuhlicke, C. (2013) - The risk perception paradox—implications for governance and communication of natural hazards. Risk analysis, 33(6), 1049-1065, https://doi.org/10.1111/j.1539-6924.2012.01942.

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Seismic risk communication in Europe over the last two decades

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Introduction

Risk communication is a key component of risk management. It can raise risk awareness, increase preparedness and promote the adoption of protective measures before, during and after disaster events. To enable risk reduction and resilience, risk communication should be a two-way, dynamic and interactive process, rather than a one-way transfer of information from experts to citizens.

Since the Seveso Directive I (1982), international guidelines such as the Yokohama Strategy (IDNDR, 1994), the Hyogo Strategy (UNISDR, 2005) and the Sendai Framework (UNISDR, 2015-2030) have recognized the potential of risk communication to promote community empowerment. From the Yokohama Strategy to the Sendai Framework, communication approaches have evolved from the prevailing one-way model to more comprehensive transdisciplinary strategies that envision working directly with communities at risk to motivate them to take precautionary action. The Sendai Framework promotes communication approaches that are tailored to the needs and capacities of different groups and communities. It emphasizes the importance of a whole-of-society approach to risk communication that involves all stakeholders, including governments, civil society, the private sector, academia, the media and communities. Effective communication requires different strategies for each disaster phase: mitigation, preparedness, response and recovery. An analysis of risk communication strategies can be found in the mid-term review of the implementation of the Sendai Framework (United Nations Official Documents, 2023). Nevertheless, an in-depth analysis of earthquake risk communication practices is still a research gap. This study aims to fill this gap by focusing on seismic risk communication and its development in Europe.

Methodology and analysis

We applied the scoping review method (see Musacchio et al., 2023 and reference therein) and structured our analysis around the following questions: “What are the main characteristics of earthquake risk communication practises and research in Europe?” and “Have they changed over time?”. To answer these questions, we analysed selected publications from three scholar databases, i.e., Scopus, Web of Science and Google Scholar, to obtain the most comprehensive overview of scientific publications.

Before beginning our analysis, we examined how the literature on seismic risk communication has evolved over time, starting in 1970. The Google Scholar database shows that the number of

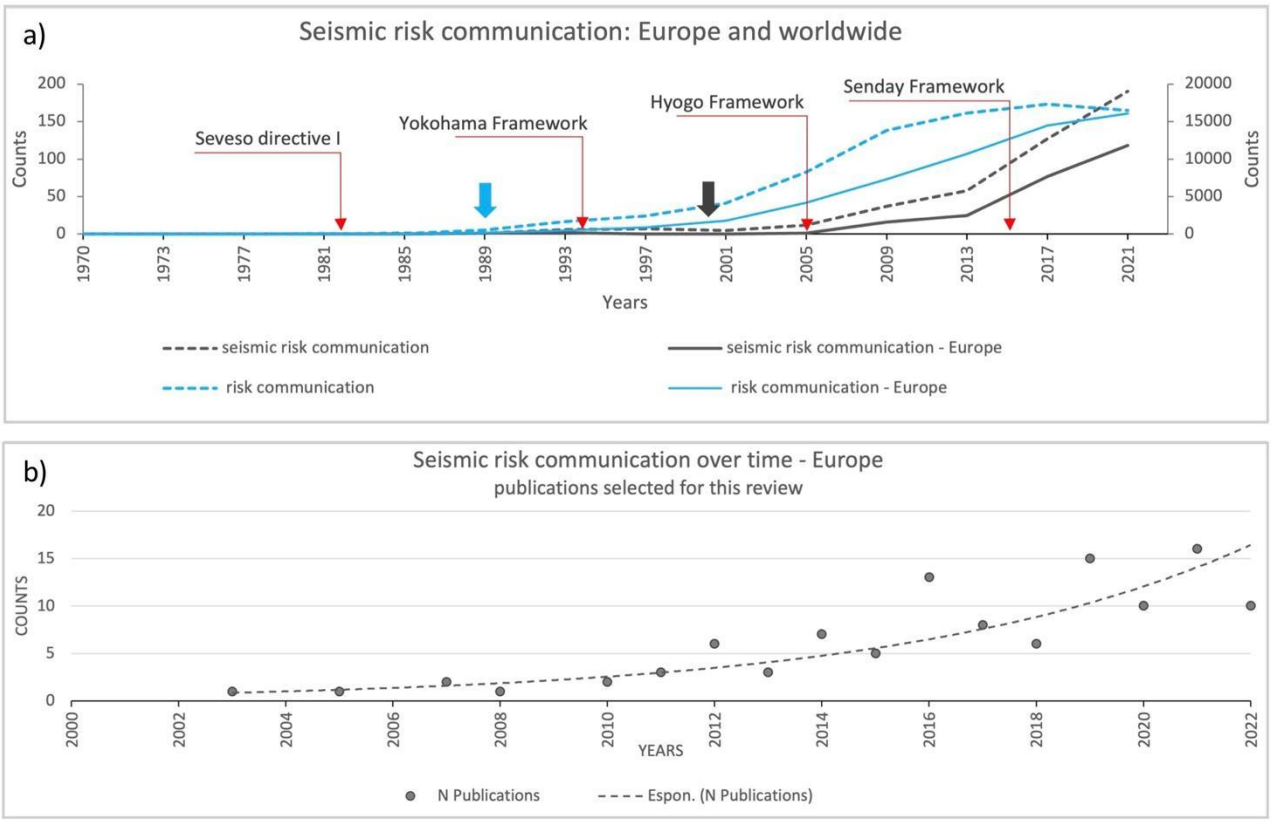

Fig. 1 – a) Publications on seismic risk communication over time. Raw data from Google Scholar database searches according to the strings listed in the text are plotted for all risks (right y-axis) and seismic risk communication (left y-axis) in Europe and worldwide; b) publications shortlisted for this review study.

publications increased significantly after the year 2000 (Fig. 1a), whereas it was negligible before. Therefore, we filtered out publications with the following terms in the period 2000-2022 (Fig. 1b): seismic risk communication; earthquake risk communication; seismic risk education; earthquake risk communication; educational seismology; seismic risk education campaign(s); seismic risk awareness campaigns. Other criteria included peer-reviewed full-text publications in English and case studies from European countries. Some additional documents were found via citations in the selected publications.

We shortlisted 482 documents that underwent further screening after reading the title, abstract or main text to remove duplicates, grey literature (conference proceedings, abstracts, reports, dissertations, web documents, magazine/newspaper articles), documents not strictly focused on earthquake risk communication or not dealing with case studies in Europe. Finally, 109 publications were considered for the scoping review (see Musacchio et al., 2023 for more details).

The 109 selected publications were examined on the basis of six key aspects of risk communication (Fig. 2), namely when the communication takes place, who communicates what to whom, why and how. We divided the publications among all co-authors in order to be able to read and categorise them in detail.

Results

The interest of the scientific literature in the communication of seismic risks seems to begin shortly after the Hyogo framework (Fig. 1a). The first paper in our selected collection was published in 2003 (Fig. 1b); the analysed publications were mainly published in geoscience journals (45%), risk or disaster journals (18%) and books (17%). The main topics covered are disasters, preparedness, risk perception and social issues, and the most frequently mentioned country is Italy. Following the structure of the key questions described in the previous section (Fig. 2), we summarise the main findings below (more details are reported in Musacchio et al., 2023).

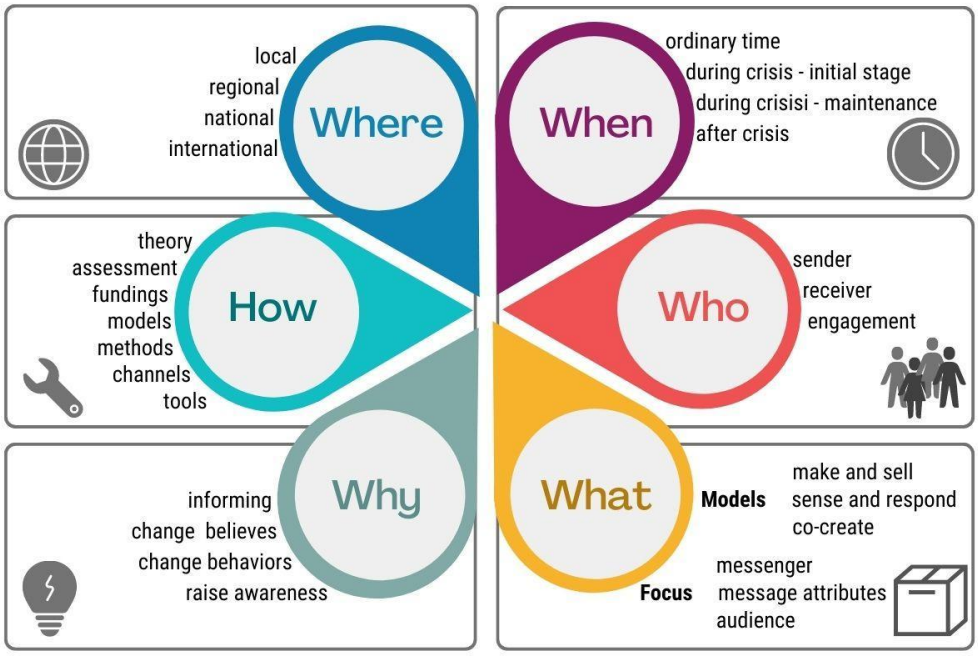

Fig. 2 – Issues under investigation for the screening of the selected publications.

When - The overwhelming majority of the selected documents (75%) dealt with earthquake risk communication in ordinary time (Fig. 3a) i.e., in the pre-event phase of the disaster risk management life cycle.

Who - Research centres and universities are among the main senders/organisers of communication activities (72%). Pupils and students (40%) and citizens (27%) are the main recipients. Recipient engagement is described in about half of the publications (46%). The vast majority use a joint development or implementation model between experts and the public, while only a few publications describe a joint evaluation model.

What - Since 2013, the two-way (43%) communication model (see Stewart et al., 2023 for description of the communication models) has been the most widely used (Fig. 3b). However, the one-way model is still mentioned in a fairly large number of publications (29%). Interestingly, the three-way model ("instruct and co-create") was adopted by less than 20% of authors, although its prevalence increased over time.

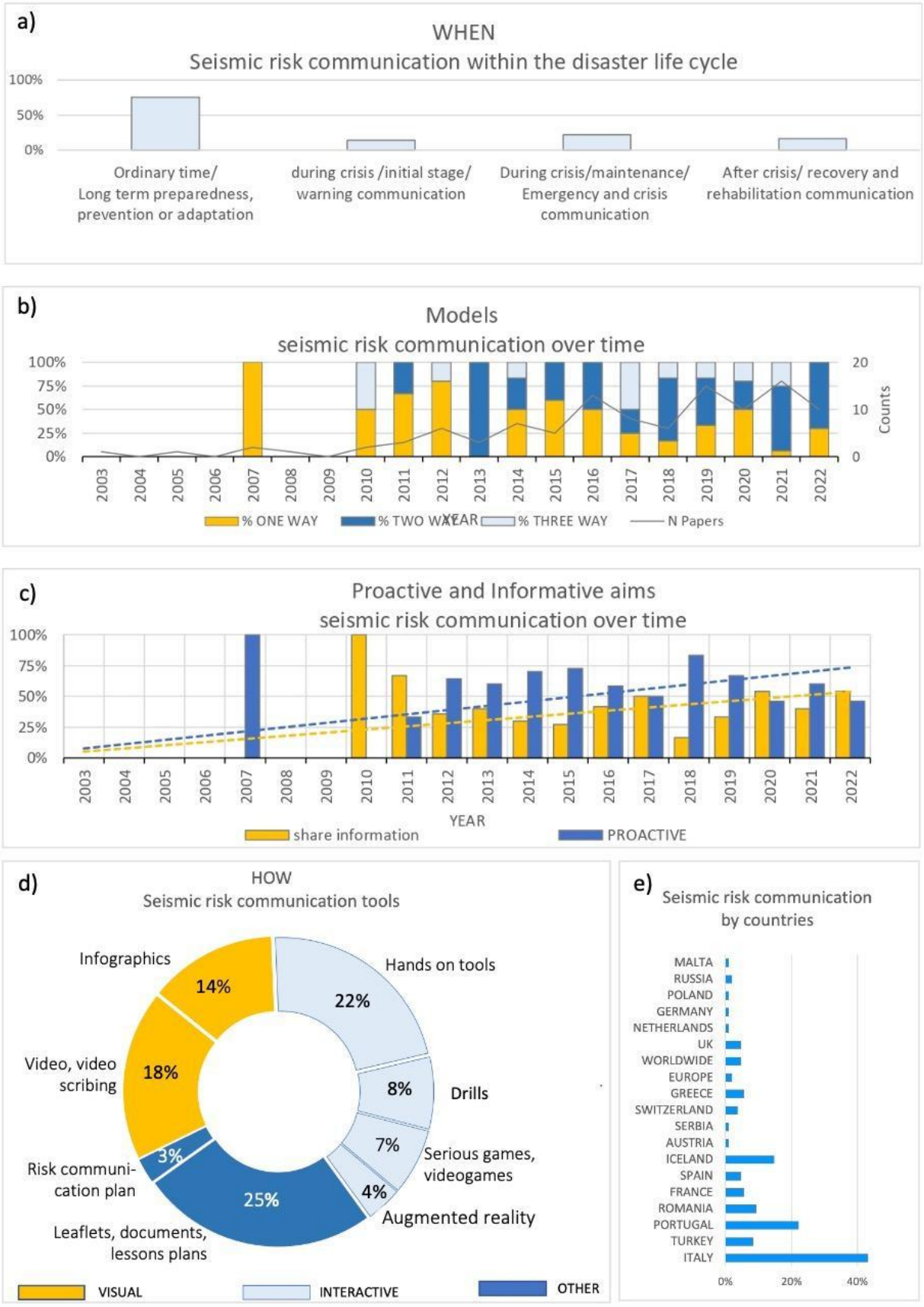

Fig. 3 – a) The selected publications on seismic risk communication within the disaster life cycle; b) the communication models used over time; c) the communication objectives mentioned in the publications; d) the tools used for communication; e) Countries of the case studies reported in the selected publications.

Why - The stated goals of seismic risk communication (multiple responses) are to share information (62%), raise awareness (47%), change behaviours (27%), change beliefs (16%), and increase preparedness (4%). Over time, communication has become more proactive than informative (Fig. 3c).

How - Interactive and visual language tools were mentioned most frequently, regardless of the temporal distribution (Fig. 3d). Serious games and augmented reality have only appeared in our data sample since the beginning of 2016. Personal communication (face-to-face, 39 %) far outperformed the internet (7 %) and even the mass media (4 %). However, the evolution of communication techniques is clearly evident in the use of social media, which enables rapid interpersonal communication and collaboration even during disasters (e.g., Saraò et al., 2023).

The methods used for communication practices were mostly surveys (18%) and classroom activities (16%), while focus groups, outreach events and interviews were the least used. However, multiple methods were reported in 24% of publications.
Risk communication research and practice is mainly funded by public international (29%) and national (26%) institutions. Only about half of the publications report on the evaluation of the efficiency/performance of seismic risk communication. The majority of publications (80%) do not explicitly formulate their theoretical basis. When theories are mentioned, deficit and behavioural models are the most frequently cited.

Where - Seismic risk communication started at the local level with the documentation of practices implemented in different countries and then took on an increasingly international character over the years. Seismic risk communication in Europe is unevenly distributed across countries, with Italy having the highest number of documents in the analysed dataset, followed by Portugal, Iceland, Romania, Turkey, France and Greece (Fig. 3e). This could be related to our criteria for the selection of documents and does not necessarily indicate a lack of interest in seismic risk communication. However, with regard to Italy, we mention two earthquakes that had a strong impact on seismic risk communication in Italy. These are the 2002 earthquake in San Giuliano di Puglia (Mw=5.7), which led to the collapse of a school and the death of 26 children and their teacher, and the 2009 earthquake in L'Aquila (Mw=6.3) and the well-known legal dispute associated with it.

Conclusions

Although earthquakes are a threat in many countries and considerable resources have been invested in safety regulations, communities at risk often lack awareness and preparedness. In this study, we reviewed the literature on earthquake risk communication in Europe published since 2000. We analysed the approaches, messages, tools and channels used for communication and how they have changed over time. The main objectives of seismic risk communication over the last two decades were to share information, raise awareness, change behaviours/beliefs and increase preparedness. Communication has mainly taken place in the pre-crisis phase of a disaster's life cycle, when risk awareness and the ability to cope with hazards can be effectively built. Pupils, students and citizens were the main recipients of the communication activities.

Over the years, two-way, transdisciplinary and bottom-up communication models have prevailed over the one-way model. In addition, communication has increasingly aimed at encouraging proactive behaviour rather than simply informing the public. Face-to-face conversations, hands-on

activities and serious games are the main tools used to engage with the public. The findings also show the growing importance of social media to reach different audiences, provide timely and actionable information in times of crisis and engage citizens. Furthermore, communication about seismic risks is practised in different ways in different countries.

As with any review study, we recognise that the results and their interpretations apply only in the context of the selected scientific literature, which does not include grey literature and documents in languages other than English. Nevertheless, we believe that the main features we have identified provide an interesting overview of the topic and can serve as a reference for future studies. The future agenda for seismic risk communication should focus on building trust with the public, tailoring communication to their needs and moving towards a three-way model of seismic risk communication that engages stakeholders from different sectors - academia, business, government and civil society — for the common goal of earthquake safety and seismic resilience.

References

Musacchio G.; Saraò A.; Falsaperla S.; Scolobig A.; 2023: A scoping review of seismic risk communication in Europe. Front. Earth Sci. 11:1155576. https://doi.org/10.3389/feart.2023.1155576

Saraò A.; Tamaro A.; Sandron D; Slejko D.; Rebez A.; 2023: On the crowdsourcing of macroseismic data to characterize geological settings. Int. J. Dis. Risk Red. 96: 103934, https://doi.org/10.1016/j.ijdrr.2023.103934

Stewart I.S.; Sevilla E.; Barragán K.; Yahya Menteşe E.; 2023: Disaster risk communication requires dissemination, dialogue and participation. Nat. Rev. Earth. Environ 4. https://doi.org/10.1038/s43017-023-00506-w

United Nations Official documents (2023). Main findings and recommendations of the midterm review of the implementation of the Sendai framework for disaster risk reduction 2015–2030. https://www.undrr.org/publication/report-main-findings-and-recommendations-midterm-review-implementation-sendai-framework

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Schools-tailored activities to communicate seismic risk

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INTRODUCTION

Risk communication is a crucial element in the management of risks: it has a great potential to raise awareness, increase preparedness, and promote legislative interventions.

Uncertainty, lack of scientific knowledge, misunderstanding, misinformation, cognitive bias, and distrust in authorities are among the major threats of effective risk communication. Nonetheless recent studies have highlighted that seismic risk communication practices have been increasing during the last decades although still more work needs to be done (Musacchio et al., 2023).

There are different models of risk communication: the majority refer to the public understanding paradigm, in which information are given in a “one-way” direction to the public, and to the public engagement paradigm, in which stakeholders are meant to participate in the building process of knowledge. In preparing a risk communication campaign, the school target has revealed as one of the most important to address, given its high potential to influence a risk-resilient society (Musacchio & Solarino, 2019).

In this paper, activities to communicate seismic risk communication specifically designed to engage middle school students are presented. Science communication with teen audiences has a unique challenge: there is a fundamental need to design activities that can help them feel involved.

The work presents the framework within which the activity is done. It describes the communication goals, learning methodology and present some of the activities that have been included in a format suitable for open-door outreach events. The activities discussed in this work were tested within two open-doors events that were held at the Milano division of the National Institute for Geophysics and Volcanology in the year 2023.

BACKGROUND FRAMEWORK

In Italy according to OPCM 3274 of 2003, 4 seismic zones were established. Highest hazard areas are spread along the Apennine, in the south and eastern part of the country. The Lombardy region is among the areas where seismic hazard is relatively low. Most of its land belongs to Seismic Zones 3 and 4 (Fig. 1).

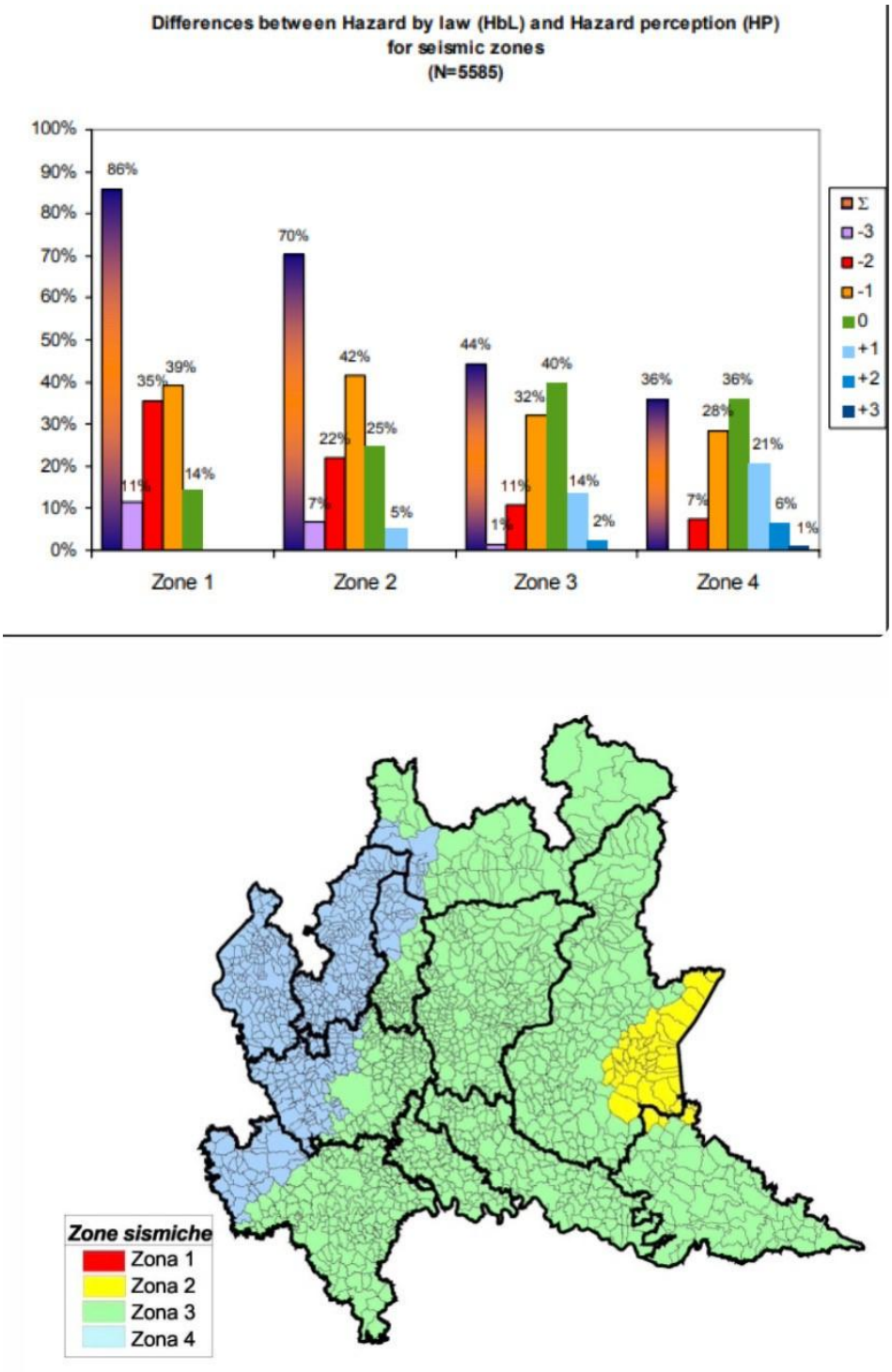

Fig. 1: Real and perceived seismic hazard. The diagram presents the frequency distribution of differences in hazard perception for Italian seismic zonation (Crescimbene et al., 2015); the map displays the seismic classification of the Lombardy region where no more than 40% of the population perceives seismic hazard properly.

The Milan Metropolitan area is located in the seismic zone 3 at the lower limit of the peak ground acceleration range of 0.05g-0.075g. This range is expected to cause damage to non-structural elements of buildings, which is typically underestimated in many European countries (Ferreira et al., 2021). Most of the buildings and infrastructures are likely to be vulnerable to such damage as specific measures are not provided by the building code.

The Milan metropolitan area's relatively low-risk level is not in line with its real risk, which affects densely populated areas with strategic infrastructure. This brings the earthquakes' issue prone to be mostly underestimated. Recent studies highlight a low-risk perception (Crescimbene et al., 2015; Crescimbene et al., 2016) that might cause communities to be unprepared to cope with the hazard.

Two earthquakes of low magnitude have shaken the area surrounding Milan in the last two years, which people did not expect but were clearly felt. On December the 17th 2020 a Mw3.8 earthquake occurred southwest of Milan next to the town of Pero; one year later, on December the 18th 2021 a Mw3.9 earthquake occurred northeast of Milan next to the city of Dalmine. They both drew attention on the seismic risk of the area. But since risk perception is still low the community is likely to be heavily unprepared.

The school context also shows the underestimation of seismic risk. The perception of seismic hazard in schools' staff and students is mostly incorrect (Bandecchi et al., 2019). Moreover there is a lack in staffs' competence to educate students to risk prevention and textbooks do not provide specific information on the topic (Musacchio et al., 2020). For these reasons, it is critical for the seismic risk subject to be more included in the school programs, and to engage students in risk communication campaigns, so they can contribute to promote awareness and preparedness on seismic risk in the society.

METHODS

The Milano Division of the Istituto Nazionale di Geofisica e Vulcanologia annually hosts schools and undertakes with them activities highly interactive mostly framed in the serious gaming approach. In this work we select educational laboratories and activities to describe three aspects of seismic risk: (1) the role of seismic site effects on the ground shaking, (2) buildings response to ground shaking and (3) key-issues on community preparedness.

The role of seismic site effects on the ground shaking: the Site-effects laboratory

Seismic site effects are a cause of damage that is often unknown by the general public. Geological, geomorphological, and geotechnical conditions modify the amplitude and frequency of seismic motion as it propagates in the final layers of soil before reaching the surface. Lithostratigraphic (Cara et al., 2019) or topographic (Massa et al., 2014) amplifications or induced phenomena, such as landslides, avalanches, or the liquefaction of sandy soils are examples of seismic site effects. A recent example that has reached the public debate in the media occurred during the 2012 Emilia earthquake sequence (Emergeo working group, 2012).

During outreach events for the secondary school, we show models displaying some aspects of seismic site effects (Fig. 2a). Two seismometers installed into sand and gravel filled buckets are used to show lithostratigrafic seismic amplification. A jump by students simulates earthquake shaking and waveforms from the seismometer installed on soft soil (sand) are visually compared with those recorded on hard soil (gravel).

Soil liquefaction is shown with a model of buildings at a small scale placed on top of water-saturated sand. A small engine shakes the sand until the typical shear strength is drastically reduced by the increasing pore pressures. The phenomenon can be observed by the appearance of water that overturns scaled models of buildings.

Buildings response to ground shaking: the Shake-It! Laboratory

The general public often asks questions such as “why do buildings collapse?”. To explore in depth the concept of vulnerability to seismic ground shaking, a laboratory about buildings’ resonance has been implemented. The dynamic characteristics of buildings play an important role in predicting their seismic behaviour and therefore their vulnerability. This parameter is highly important during an earthquake, since, if an earthquake carries significant energy near the natural period of the structure, or if the foundation’s soft soil has its predominant period near the structure’s period, the physical phenomena of resonance could happen (Mucciarelli et al., 2002).

In the “Shake it!” laboratory key aspects of this concept have been addressed highlighting that the largest oscillations occur when earthquake frequency matches the building’s natural frequency. A metal structure building-model placed on a unidirectional small-scale educational shaking table was used to visualize the downscale phenomenon of earthquake building resistance. A wi-fi accelerometer placed on top of the building, and a second one on the platform, that Is at the base of the building-model, were used to measure the ground-shaking displayed on a monitor. A real earthquake and a synthetic sinusoidal signal, in a 2Hz to 10Hz frequency range, were used as input for the shaking table. While the real signal was used to highlight the difference between the shaking at the ground and that on top of the building, the synthetic sinusoidal allowed to visualize the phenomenon of the resonance (Fig. 2b).

After watching the shake table experiment the class was asked to make its own experiment. The building-model had to be done using spaghetti and marshmallows and the shake table was made by a cardboard platform on top of a small electrical engine. The challenge was to build the frame structure as tall and stable as possible. To have a more stable structure it was suggested to add braces. The building-models were placed on the shake-box to verify its seismic performance (Fig. 2c).

Key-issues on community prevention and preparedness: Videogaming activity

Risk communication must enhance both prevention and preparedness to a seismic event. These concepts could be summarized by two key questions:

-why should I care about seismic risk?

-what can I do to protect myself?

We used 3 interactive videogames to address the above questions. These videogames have been designed in the framework of the ENP-CP project on the Seismic Risk Sensibilization, and successfully used in interactive hybrid events for the schools (Goretti and Musacchio, 2022). We chose the games not only as a tool to better capture the teenagers' attention but also to aid them get across some otherwise heavy-handed subjects.

The first question was addressed with the videogame "Catch the Plate" that is based on Plate Tectonics. The activity helps acknowledge that earthquakes are a natural phenomenon. Emphasis is placed on the knowledge of the territory where one lives, the geological features characterizing it and therefore the seismic hazard.

The second question was answered by highlighting the need to be prepared as a mean to prevent damage and be able to cope with emergency situations. Two games address this question and provide suggestions concerning those actions that can make the difference in case of an earthquake. The game "Make your room ready" ask the players to decrease seismic vulnerability in the places where youth spend most of their time during the day (i.e., bedroom, classroom). It stands upon three keywords matching crucial simple actions that can reduce seismic vulnerability to non-structural elements inside a building, and namely move-protect-secure (Ferreira et al., 2020).

The game "Emergency bag" highlights that as we live in a seismic country, it is fundamental to know how to cope with the issue of evacuation in case of an earthquake. The April 6th, 2009, L'Aquila event is just an example of an earthquake catching people off-guard in the middle of the night. Thus, it is crucial to have an emergency bag to be ready to go out of a building with only the most useful stuff. The game wants to make young people think about proper objects to stay a few hours away from home.

The take-home message is to be ready for a seismic event means to know where I live and how to act in the most efficient and safe way.

Fig. 2: Snapshots of the activities implemented in 2023 at the Milano Division of the Institute of geophysics and Volcanology during the events of ScienzAperta for schools and the Week of Planet Earth. From top to bottom: "Site-effects" laboratory: analogue models for the lithostratigraphic amplification and liquefaction (a); Shake it!" laboratory: a ground shaking simulation using an educational small-scale shaking table (b) and an example of a marshmallow building frame structure placed on the shake box (c); "Videogaming" activity: prevention and preparedness issues addressed with videogames (d).

CONCLUSION AND DISCUSSION

In this paper, a format for seismic risk communication specifically designed to engage middle school students is proposed, with the aim to increase scientific knowledge, and promote the awareness in the community about the seismic risk.

In the Lombardy region seismic hazard is relatively low since most of its land belongs to Seismic Zones 3 and 4. The relatively low hazard level of the Milan Metropolitan area is apparently at odds with the actual risk. Moreover, in the last two years the area surrounding Milan was shook by two low magnitude earthquakes that people clearly felt, and that were yet unexpected.

The Milano Division of the Istituto Nazionale di Geofisica e Vulcanologia is engaged in science communication activities that are intended for a school audience. Although schools are referred to as a strategic public in risk communication to build a risk-resilient society, topics addressing seismic risk are underestimated in educational programs. It's critical to invest more in the design of effective seismic risk communication campaigns for the school target.

The format described in this paper includes three activities: in the Site effects laboratory we show models displaying some aspects of these phenomena; in the Shake-it! laboratory seismic vulnerability is discussed through an experiment on scaled-down shaking table model and by letting the students reproduce it with marshmallows, spaghetti and a cardboard shaking-table; finally, we propose video games designed to learn where do earthquakes usually occur, how to secure the house from ground shaking and how to get ready for a seismic emergency. The three activities share features responding to modern communicative and didactic methodologies, inspired on active learning, that has proven to be one of the most effective in enhancing students' capability in achieving an in-depth knowledge in STEM disciplines (Freeman et al., 2013; Michael, 2006). Interactivity, team play, problem-solving, hands-on activities, multiple communicative channels, from graphic to linguistic, are the techniques used to contrast the students' disengagement and by doing this to adapt the seismic risk communication campaign to the specific target. All these techniques stood on the fruitful interaction between students and scientists.

Each activity had a focus on a single aspect of the seismic risk, to raise from time-to-time awareness on the different factors involved in seismic risk: the site effects, the buildings vulnerability, and the preparedness were addressed one by one allowing students to strengthen their understanding of specific scientific concepts. The digital game-based learning proposed in the preparedness laboratory has shown as one of the most effective ways to communicate with the so called "millennial" students, a digital native generation with specific concentration attitudes (Roelh et al., 2013).

The activities were tested within the two open-doors events that the Milano Division of the Istituto Nazionale di Geofisica e Vulcanologia offered to schools in the year 2023 hosting about 200 students and teachers.

An excellent participation among students and teachers was recorded, with students actively collaborating with each other during hands on activities and showing a great curiosity towards the seismological models. Videogames confirm their effectiveness in capturing the teenagers' attention, aiding them to get across some otherwise heavy-handed subjects. A recap-game was used to understand to what extent the proposed concepts were grasped: students had to fill a text with words representing the topics addressed during the activities. The results indicate the efficacy of this methodology to communicate risk to schools and reiterate the need to increase the communication practices for this specific form of risk.

Acknowledgements

The videogames presented in this work have been implemented within the ENP-CP European Neighbourhood Policy - Civil Protection (ENP-CP) EU-funded project. The activities are a follow-up of the "Know your city, Reduce seISmic risK through non-structural elements" (KnowRISK) DG-ECHO program funded project. They are also based on the exhibition "Terremoti: Attenti agli Elementi!-Dettagli che salvano la vita" that was presented at the 2019 edition of the Genova Science festival.

References

Asteris P. G., Tsaris A. K., Cavaleri L., Repapis C. C., Papalou A., Di Trapani F., & Karypidis D. F. (2016). Prediction of the fundamental period of infilled RC frame structures using artificial neural networks. Computational Intelligence and Neuroscience, 2016, 20-20.

Bandecchi A. E., Pazzi V., Morelli S., Valori L., & Casagli N. (2019). Geo-hydrological and seismic risk awareness at school: Emergency preparedness and risk perception evaluation. International journal of disaster risk reduction, 40, 101280.

Cara F., Cultrera G., Riccio G., Amoroso S., Bordoni P., Bucci A., ... & Mancini M. (2019). Temporary dense seismic network during the 2016 Central Italy seismic emergency for microzonation studies. Scientific data, 6(1), 182.

Crescimbene M., La Longa F., Camassi R., & Pino N. A. (2015). The seismic risk perception questionnaire. Geological Society, London, Special Publications, 419(1), 69-77.

Crescimbene M., La Longa F., Pessina V., Pino N. A., & Peruzza L. (2016). Seismic Risk Perception compared with seismic Risk Factors. European Geosciences Union General Assembly.

Emergeo Working Group. (2013). Liquefaction phenomena associated with the Emilia earthquake sequence of May–June 2012 (Northern Italy). Natural Hazards and Earth System Sciences, 13(4), 935-947.

Ferreira M.A., Oliveira C.S., Lopes M., Mota de Sá F., Musacchio G., Rupakhety R., Reitano D., Pais I. (2021) Using non-structural mitigation measures to maintain business continuity: a multi-stakeholder engagement strategy. Annals of Geophysics, 64, 3, https://doi.org/10.4401/ag-8559

Freeman S., Eddy, S. L., McDonough M., Smith M. K., Okoroafor N., Jordt, H., & Wenderoth M. P. (2014). Active learning increases student performance in science, engineering, and mathematics. Proceedings of the national academy of sciences, 111(23), 8410-8415.

Goretti A., and Musacchio G. (2022). Report on the Interactive Hybrid Event@Schools on Seismic Risk Sensibilisation, Activity 4.3 Participation to MS awareness and educational campaigns, WP4 Strengthening awareness raising initiatives and educational campaigns in the area of seismic risk, Preparedness action for European Neighbourhood Policy countries – Civil Protection Project (ENP-CP). Agreement No. ECHO/SUB/2019/B1/816935

Massa M., Barani S., & Lovati S. (2014). Overview of topographic effects based on experimental observations: meaning, causes and possible interpretations. Geophysical Journal International, 197(3), 1537-1550.

Mayhew M. A., & Hall M. K. (2012). Science Communication in a Café Scientifique for High School Teens. Science Communication, 34(4), 546-554. https://doi.org/10.1177/1075547012444790

Michael J. (2006). Where's the evidence that active learning works?. Advances in physiology education.

Mucciarelli M., Masi A., Gallipoli M. R., Harabaglia P., Vona M., Ponzo F., & Dolce M. (2004). Analysis of RC building dynamic response and soil-building resonance based on data recorded during a damaging earthquake (Molise, Italy, 2002). Bulletin of the Seismological Society of America, 94(5), 1943-1953.

Musacchio G., Eva E., Crescimbene M., Pino N. A., & Cugliari L. (2021). A protocol to communicate seismic risk in schools: design, test, and assessment in Italy. Annals of Geophysics.

Musacchio G., Falsaperla S., Solarino S., Piangiamore G. L., Crescimbene M., Pino N. A., ... & Accardo M. (2019). KnowRISK on seismic risk communication: The set-up of a participatory strategy-Italy case study. In Proceedings of the International Conference on Earthquake Engineering and Structural Dynamics (pp. 413-427). Springer International Publishing.

Musacchio G., Saraò A., Falsaperla S., & Scolobig A. (2023). A scoping review of seismic risk communication in Europe. Frontiers in Earth Science, 11, 1155576.

Roehl A., Reddy S. L., & Shannon G. J. (2013). The flipped classroom: An opportunity to engage millennial students through active learning. Journal of Family and Consumer Sciences, 105(2), 44.

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Seismic risk perception in italian hospitals: The role of non-structural elements

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INTRODUCTION

The ENRICH (ENhancing the Resilience of Italian HealthCare and Hospital Facilities) project deals with seismic resilience of hospitals and healthcare facilities. It is a three-years project funded by the Ministry of University and Research as part of the major national interest programme, PRIN, 2022-2025, led by the University of Neaples Federico II and involving the Universities of Sannio and Salento, the Istituto per le Tecnologie della Costruzione of the National Research Council and the Istituto Nazionale di Geofisica e Vulcanologia.

Seismic performance of non-structural elements and their functional adaptability are the two pillars of ENRICH. However, since regulatory provisions are likely to become more effective if stakeholders are aware of the associated risks and benefits (Solarino et al. 2020; Musacchio et al. 2021), the project couple engineering technological advancement to risk perception studies.

Hospitals are at the forefront of responding to disasters, including those associated with earthquakes, providing essential medical care, public health services and coordination efforts to mitigate the impact of disasters on individuals and communities by providing immediate assistance to those affected. Furthermore, in addition to receiving and treating patients, they must be able to ensure prevention for any epidemics.

The disproportionate impact of earthquakes on critical structures such as hospitals can often be attributed to the inadequate seismic response of non-structural elements. While the structural integrity of buildings is crucial, the non-structural components and systems within such buildings play a significant role in ensuring the continued functioning of essential structures during and after an earthquake. Damaging these elements would mean hindering the overall functionality of healthcare facilities.

Risk perception is a key element in the definition and adoption of preventive countermeasures. To develop effective risk information and communication strategies, it is necessary to know risk perception and the factors that influence it (Slovic, 1987; Peters & Slovic, 1996; Renn, 2008).

METHODS AND RESULTS

The objective of this research was to investigate (1) how the healthcare facilities' staff perceives the seismic risk in their workplace and territory, (2) how they perceive the risk associated with the non-structural elements in the hospital buildings, and (3) what are in their opinion the main factors influencing risk. At this purpose, a mixed methodology that combines quantitative and qualitative techniques was adopted, consisting on a focus group and a survey, and it was proposed to the healthcare staffs in the pilot sited selected in the framework of the ENRICH project. The pilot sites were the Lecce healthcare unit, and the Caserta healthcare unit, both in the South of Italy. These two pilot sites are located in two different seismic hazard areas: Lecce is located in the low-to-moderate seismic hazard area 4, while the Caserta area is area 2, where strong earthquakes are possible.

The focus group was implemented in order to achieve an in-depth knowledge about the subject of seismic risk perception: it was offered a list of assessed questions, starting from the general topic of the personal experience with earthquakes and progressively went into detail about the seismic risk perception in the healthcare framework and the prevention issue, but encouraging the spontaneous contribution of participants. The analysis of data has followed the grounded theory framework, by applying a coding process to the text extrapolated from the discussion and creating general interpretative categories basing on that code (Sargent et al., 2016). The quantitative questionnaire was expressly designed to measure the seismic risk perception in healthcare staff: it includes 10 sections with questions evaluating the resilience of the hospital structure, of non-structural elements, of the territory, and of the staff itself, to score on a semantic differential for each item.

Results from preliminary analysis on the data collected indicate that there is an underestimation of the risk, both as regards the geographic areas, respectively Lecce city and Caserta city, and as regards the role of non-structural elements in determining the damage inflicted by an earthquake. However, the participants seem generally aware that the risk is underestimated, and the importance of prevention seems to be properly perceived. Moreover, both groups looked very curious, especially about geological and scientific issues, and eager to fill the knowledge gap by means of informative events and initiatives addressing specifically the seismic risk topic.

The aim of the ENRICH project by conducting this research is to actively involve the healthcare facilities' staff in the risk communication process, and to use the gathered data and suggestions in the developing of future risk communication strategies and campaigns, more effective and more targeted to the communities to address. One of the tasks scheduled by the project is the informative materials production, including that of a citizen-science app, and the design of

informative events in order to raise awareness towards the seismic risk and the non-structural elements resilience, in the healthcare framework and among the general public.

REFERENCES

Musacchio G., Eva E., Crescimbene M., Pino N.A., Cugliari L. (2021). A protocol to communicate seismic risk in schools: design, test and assessment in Italy. *Annals of Geophysics*, 64, 3, https://doi.org/10.4401/ag-8533.

Peters E., Slovic P. (1996). The role of affect and worldviews as orienting dispositions in the perception and acceptance of nuclear power. *Journal of Applied Social Psychology* 26(16):1427–1453.

Renn O. (2008). Risk governance: coping with uncertainty in a complex world. Earthscan, London, p. 110.

Sargent S., Samanta J., & Yelden K. (2016). A grounded theory analysis of a focus group study. *SAGE Research Methods Cases Health*.

Slovic P. (1987). Perception of risk. *Science* 236:280–285.

Solarino S., Amaral Ferreira M., Musacchio G., Rupakhety R., O'Neill H., et al. (2020). What scientific information on non-structural elements seismic risk people need to know? Part 2: tools for risk communication. *Annals of Geophysics* 2020; 63(Vol 63): 2.

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