Tsunami risk perception in Central and Southern Italy.

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Abstract

The Tsunami Warning Center of the National Institute of Geophysics and Volcanology (CAT-INGV) has been promoting, since 2018, the study of tsunami risk perception in Italy. Between 2018 and 2021 the semi-structured questionnaire on the perception of tsunami risk was administered to a sample of 5,842 citizens residing in 450 Italian coastal municipalities, representative of more than 12 million people. The survey was conducted with the Computer Assisted Telephone Interview (CATI) methodology, described in Cerase et al. (2019) who published the results of the first pilot survey (about 1,000 interviews). The large sample and the socio-demographic stratification give an excellent representation of the resident population in the surveyed Italian coastal municipalities. Moreover, in 2021 an optimized version of the questionnaire was also administered via Telepanel (a tool for collecting proportional and representative opinions of citizens) representative of the Italian population, which included 1,500 people distributed throughout the country.

In this work we present the main results of the three survey phases, with a comparison among the eight surveyed regions, and between the coastal regions and some coastal metropolitan cities involved in the investigations (Rome, Naples, Bari, Reggio Calabria and Catania).

Data analysis reveals heterogeneous and generally low tsunami risk perception. Some seaside, in fact, show a good perception of tsunami risk while others, such as in Apulia and Molise, reveal a lower perception, most likely due to the long time elapsed since the last event and the lack of memory. We do not find relevant differences related to the socio-demographic characteristics (age, gender) of the sample, whereas the education degree appears to affect people's perception. The survey shows that the respondents' predominant source of information on tsunamis is the television and other media sources (such us newspapers, books, films, internet etc.) while the official sources (e.g. civil protection, local authorities, universities and research institutes) do not contribute significantly. Also, we found an interesting difference in people's understanding of the words tsunami and maremoto, the local term commonly used in Italy until the 2004 Sumatra event, which should be taken into account in scientific and risk communication. The Telepanel survey, based on a nationwide sample, highlights a lower level of tsunami risk perception in comparison to average risk perception levels found in the coastal municipality sample.

Our results are being used to drive our communication strategy aimed at reducing tsunami risk in Italy, to activate dissemination and educational programs (data driven), to fill the data gap on tsunami risk perception in the NEAMTWS area, and to implement multilevel Civil Protection actions (national and local, top-down and bottom-up). Not least, outputs can address a better development of the UNESCO-Tsunami Ready program in Italy.

1. Introduction

The Mediterranean region is highly exposed to tsunami risk, as witnessed by several recent events (Yalçıner et al., 2017; Dogan et al. 2021; Kalligeris et al., 2022), basin-wide or local historical events (Maramai et al., 2014; Papadopoulos et al., 2014; Solov′ev et al., 2000; Maramai et al., 2021), and by the recent assessment of seismically induced tsunami hazard (Sørensen et al., 2012; Basili et al., 2021). However, the tsunami risk in the Mediterranean is thought to be underrated, due to the low frequency of events, as for other regions of the world (Dawson et al., 2004; Dogulu et al., 2014; UNESCO-IOC, 2017; Amato, 2020; Necmioğlu et al., 2021). It is therefore important to raise awareness among people, as well as of local authorities responsible for civil protection measures and emergency management, and national / regional authorities.

The Sendai Framework for Disaster Risk Reduction 2015-2030 gives high attention to Early Warning Systems (EWS), suggesting to "invest in, develop, maintain and strengthen people-centered multi-hazard, multisectoral forecasting and early warning systems, …; develop such systems through a participatory process; tailor them to the needs of users, including social and cultural requirements, in particular gender…". The strong emphasis on people means that any communication strategy should be based on a preliminary assessment of people's knowledge, awareness and perception of the risk. Moreover, the "needs of users" must be studied and understood, to reach people and communities in the right way using the best language and communication channels, and to have an optimal response in case of an impending inundation.

The Italian Tsunami Alert Center (Centro Allerta Tsunami, CAT) of the Italian National Institute of Geophysics and Volcanology (INGV) is part of the national Tsunami Warning System called SiAM (Italian national warning system for tsunami of seismic origin), established in 2017 with a Prime Minister Directive (G.U. n.128 del 05-06-2017). The SiAM is coordinated by the Civil Protection national Department (DPC), and besides the CAT-INGV, includes the Italian Institute for Environmental Protection and Research (ISPRA, Istituto Superiore per la Protezione e la Ricerca Ambientale) that manages the national sea level network and contributes to mapping the tsunami inundation zones. The CAT acts as Tsunami Service Provider (TSP) for UNESCO Member States of the NEAM region (Amato et al., 2021), as well as National Tsunami Warning Center (NTWC) and Tsunami Focal Point (TFP) for Italy. Among the tasks of CAT, besides the tsunami surveillance / warning and the hazard assessment, there are also scientific and risk communications activities on tsunamis. CAT manages a dedicated web site (www.ingv.it/cat/en/), where people can find information on tsunami hazard/risk, on the warning system, on historical events, news on projects, papers, campaigns and drills.

In this perspective, the activities of the CAT include assessing people's perception of tsunami risk. This research aims to improve risk analysis and decision making, develop methods for eliciting opinions about risk, provide a basis for understanding and anticipating possible public reactions to tsunami hazards, enhancing risk communication among lay people, technical experts and policy makers (Slovic et al., 1982; Slovic, 1987; Wildavsky and Dake, 1990; Slovic, 2001; Rippl, 2002).

This paper presents the data on tsunami risk perception collected in Central and Southern Italy between 2018 and 2021. The study involved the administration of a semi-structured questionnaire to a sample of 5,842 people in 450 coastal municipalities.

Codice campo modificato

2. Studies on tsunami risk perception, a brief overview

Risk perception studies taking into account the socio-cultural and psychological aspect, assess people's response to natural hazards and the behaviors they would adopt in response to the risks. People's perceptions - individually or collectively - of a natural hazard are also influenced by individual factors such as personality, age, beliefs, gender, education level, knowledge, and culture (Slovic, 1982; Slovic and Peters, 2006; McIvor et al., 2009; McNeill et al., 2013; Wachinger et al., 2013).

Human behavior is driven by perceptions (Slovic, 1987) rather than scientific knowledge about "facts" (Renn, 1990). Therefore, it becomes strategic for those involved in risk mitigation and communication, to have in-depth studies on the process that influences our ability to assess the risk of a natural phenomenon (Slovic, 1982) like tsunamis. Tsunamis are known to be a phenomenon with a low probability of occurrence but high impact, able to produce devastating consequences that would affect large areas and have serious consequences for human lives (Behrens et al., 2021; Rafliana et al., 2022). The low frequency of occurrence is one of the variables that directly affects risk perception. In some Mediterranean areas (such as Italian coastal regions), tsunami appears to be out of the collective consciousness, eventually inducing authorities in underestimating risk perception relevance, and in taking effective actions to reduce the risk.

However, tsunamis' low frequency of occurrence does not reduce their destructive potential. Moreover, how important it is to study people's perceptions of natural hazards (Lindell, 2000; Paton, 2010; Wachinger, 2013; Bonaiuto, 2016), particularly tsunami risk perceptions, emerges in various studies conducted in countries that were affected by tsunamis, such as for example, the 2004 Indian Ocean tsunami or the 2011 Japan tsunami (Kurita et al., 2007; Sugimoto et al. 2010; Alam, 2016; Arias, et al., 2017; Akbar et al., 2020).

The historical catalog of tsunami observed effects in the Mediterranean (Maramai et al., 2014) cites over 200 documented events for the whole area, 90% of which were caused by earthquakes. More recently, in the Euro-Mediterranean area, 31 earthquakes above magnitude 5.5 occurred at sea or near the coast between 2017 and October 2022, triggering the activation of CAT. Among them, 10 earthquakes generated an alert level for possible sea level change, including 6 Advisory (possible sea level change with estimated run-up less than 1 meter) and 4 Watch (possible sea level change with estimated run-up values above 1 meter). Two of them caused damages in Greece and Turkey (Yalçıner et al., 2017; Dogan et al., 2019; Dogan et al., 2021; Triantafyllou et al., 2020; Kalligeris et al., 2022).

In addition, variables to be considered from a comprehensive perspective include the large growth in population living along the Euro-Mediterranean coasts. This phenomenon, occurring since the Second World War and intensified in recent decades, also includes the development of tourist facilities and large industrial complexes. These intensive forms of settlements require multi-risk analytical hazard approaches, where the socio-cultural and psycho-social aspect becomes prominent. In this framework, strengthening tsunami risk perception studies is needed, surveying the opinions of employees, daily commuters, seasonal workers and tourists whose presence dramatically increase the risk during holiday seasons. The need to assess tsunami risk perception has been highlighted by several authors as a key to improving emergency behaviors and minimizing population risk by limiting casualties and infrastructure damage (Ho et al., 2008; Martin et al., 2009; Ritchie and Roser, 2014; EMDAT, 2019).

Commentato [LC1]: No, the catalog just reports the tsunami effect observed and documented in coeval sources.

ha eliminato: Generally, risk perception studies do not take into account the single factors used to define risk (Hazard, Exposure, Vulnerability). In our work we try to do this in order to relate physical dimensions of the event (in terms of tsunami magnitude and impact, especially considering small tsunamis, which are more frequent in the Mediterranean context) with risk perception, as to better integrate risk perception studies within a multidisciplinary research context. …

3. The CAT-INGV tsunami risk perception studies

The CAT-INGV since 2018 has been promoting tsunami risk perception studies to provide oriented support to civil protection activities and develop data-driven, context-appropriate risk communication strategies. We have adopted the CATI (Computer Assisted Telephone Interviews) questionnaire's structuring and administration methodology since it proved to be an excellent tool to collect a large, standardized, retraceable and cost-effective amount of data (Dawson et al., 2004; Cerase et al., 2019). Furthermore, the questionnaire as a survey method to study tsunami risk perception is widely used in the international context (see for example Apatu, 2013; Sun, 2013; Lindell, 2015; Lindell, 2016; Jon, 2016; Fraser, 2016; Wei, 2017; Buylova, 2020)

3.1 The tsunami risk perception questionnaire

In this study we have used the questionnaire designed and described in Cerase et al. (2019; available in the English version in paper's SOM), consisting of 6 sections and 27 items that allow us to detect respondents' opinions regarding tsunami knowledge, risk perception, representation, cultural attitudes toward risks (Douglas and Wildavsky, 1982), and through which channels respondents have been informed about tsunamis and would like to receive an alert in case of tsunami.
This questionnaire, implemented and administered in 2018, was subsequently adopted in two other surveys carried out in 2020 and in 2021, extending the coverage to six more Italian regions and achieving a better statistical representativeness.

3.2 - Study area and sample characteristics

The coastal belts are among the most densely populated territories of the Mediterranean, where several large urban centers and some industrial activities are developed. In 2012, 40.8% of the European Union population (about 200 million) lived in coastal regions which comprising about 40.0% of EU-27 territorial extension, with an average population density of 100 inhabitants/km^2 (Eurostat, 2013). Moreover, in 2018, 28% of the Italian population (more than 17 million inhabitants) resided in coastal municipalities (ISTAT, 2020). Between 1951 and 2011, the increase in coastal population was about 29%. The 8 regions surveyed together represent about 78% of the national coastline. Coastal areas are also among the most densely populated with an average of 398 inhabitants per km^2 - with peaks of more than 500 inhabitants/km^2 in the metropolitan areas of Genova, Rome, Naples, Palermo, Catania, and Bari - compared to an average of 167 inhabitants/km^2 in non-coastal areas. (Report ISTAT[1], 2020).

Our survey was carried out in three different phases. The first survey was carried out in 2018 (April 4 to May 4) and covered Apulia and Calabria regions where 1021 questionnaires were collected (Cerase et al., 2019). In the second survey phase, carried out between Dec. 27, 2019 and Jan. 8, 2020, 614 questionnaires were collected in the coastal municipalities of Molise, Basilicata and Eastern Sicily. In the third survey phase, completed in 2021 (between Dec. 21, 2020 and Jan. 8, 2021), 4,207 questionnaires were collected in the coastal municipalities of Latium, Campania, Sardinia, southern and northern Sicily. At this stage, research only

[1] ISTAT, Italian National Statistical Institute.

considers permanent residents in coastal municipalities: therefore, seasonality is not deemed to affect the results.

The 2021 administration included all the coastal metropolitan cities of central and southern Italy (ISTAT, 2020). This is relevant for Civil Protection because Naples, Rome, Palermo Messina and Catania are some of the most densely populated Mediterranean coastal cities (UNESCO-IOC, 2020; Eurostat, 2022). Adding to these cities also Bari, Reggio Calabria and Cagliari, also sampled in 2018 and 2021, we represent about 6 million coastal inhabitants.

All these regions were chosen because southern Italy, particularly the Ionian side, have the highest tsunami hazard (Basili et al., 2019; Basili et al., 2021) compared to other Italian regions (Liguria, Marche, Abruzzo, Veneto, etc.). We are planning to complete, in the next one to two years, the questionnaire administration along the coastal areas of the remaining regions in order to have a comprehensive view of the Italian coastal territory on tsunami risk perception.

Table 1 shows the numerical distribution of the sample by survey stage and region. The survey covered a total of 8 regions, 37 provinces, achieving 69.8% coverage of coastal municipalities for a total of 6,166 km of coasts surveyed and 5,842 interviews conducted, that are considered representative of 12,484,236 residents (ISTAT, 2021).

	1st Stage		*2nd Stage*			*3rd Stage*				
	Apulia	**Calabria**	**Molise**	**Basilicata**	**Eastern Sicily**	**Latium**	**Campania**	**Sicily (except eastern)**	**Sardinia**	Total
Total Residents	1,716,797	1,120,698	43,800	58,385	834,881	3,786,704	1,925,984	2,137,306	859,721	**12,484,236**
Coastal Municipalities	67	116	4	7	29	20	40	96	71	**450**
No. Respondents	722	491	100	140	374	1,034	1,170	1,221	782	**5,842**
Total	**1021 Respondents**		**614 Respondents**			**4207 Respondents**				
	2018 / 2020 / 2021 – Territorial distribution									
	Regions		**No. of provinces**		**Coastal municipalities**	**Respondents**			**Km of coast surveyed**	
	8		**37**		**69,8%** (450/645)	**5,842** (12,484,236 pop tot)			**77,9%** (6,166km)	

Table 1. Sample distribution in the three survey stages

Figure 1 shows the geographical distribution of interviews by stage and by regions.

The sampling design was structured respecting robust statistical standards with attention to the population representativeness of even smaller coastal municipalities.

The survey sample is stratified by quota (not a probability sample). The stratification is made by territory (municipalities of coastal regions) and the quotas are identified by age and gender. In order to have a more statistically robust sample, education degree was considered as a quota for the third survey stage (n=4,207). The sample size reflects a choice to ensure 95% reliability of the estimates considering each quota as simple random sample. Thus, the overall sample design ensuring the estimates' reliability and control for sampling error variability is guaranteed.

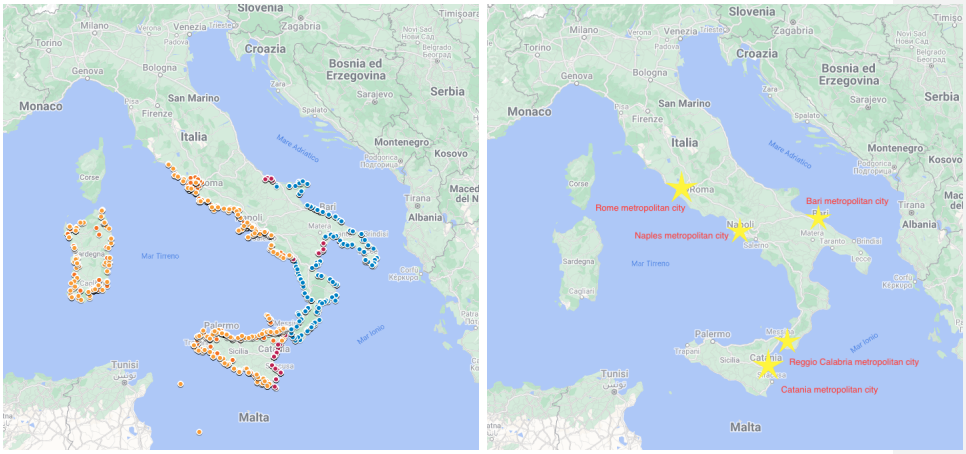

Figure 1. Maps of the CATI interview distribution (left) and coastal metropolitan cities (right). The different color circles, on the left map, indicate the interview distribution in the different survey phases: blue shows the interviews in the first survey phase (2018), red shows the second survey phase (2020), and orange shows the distribution of interviews in the third survey phase (2021). Yellow stars, on the right map, indicate metropolitan cities (provincial capitals) where population density is high for a wide territorial area. (Maps Data modified from: Google Maps, @2022)

3.3 - Sample validation for the three survey phases (Cronbach's alpha and T-test), statistical data processing

Since the three surveys were carried out in different years, a great methodological accuracy and some preliminary statistical operations to validate and verify the data were required.
First, we verified that the samples were statistically uniform, independent, and representative in estimating the reference population mean. Further, we checked whether the datasets could be aggregated into a single matrix to produce robust outputs and correlations. For this, we used the T-test (or Students' test) (Student, 1908). In our case, we applied the T-test to questionnaire's items nr. 8; 12; 14; 16; 20, which are multiple choice questions, and to 21; 23; 24, which are Likert scale questions' batteries, between the first and the second surveys (2018-2020) and between the first and third surveys (2018-2021), respectively. The results of T-test with a confidence interval of 95% confirm that the samples are statistically uniform, comparable and, consequently, analyzable in a single data matrix. The same test has been used in similar research on tsunami risk perception to compare averages of surveyed groups (see e.g., Akbar, 2020; Buylova, 2020; Musacchio, 2021; Liu, 2021).
Once obtained the T-test confirmations, we verified that the collected data were consistent and significant as a part of a robust sample. We calculated Cronbach's alpha (Cronbach, 1951; 1988) on the items comprising questionnaire sections numbers: 2, 3, 4, 5 and 6. The resulting alpha values between $0.61 \leq \alpha \leq 0.83$ are generally considered optimal to corroborate the variable reliability (Nunnally, 1975). Particularly, values near $\alpha=0.80$ or greater have an optimal consistency degree (Peterson, 1994). The alpha values resulting from our comparisons ranged from $0.74 \leq \alpha \leq 0.89$, therefore suggesting the statistical uniformity of the whole sample.

3.4 - The national sample (National Sample)

In 2021 we administered a questionnaire to a representative sample of the whole Italian Italian population distributed by proportional shares.
This has been done through a digital platform that reaches users - who are registered with the proprietary company - through a link on their smartphones (named TelePanel by the company). The link allows access to the on-line, re-adapted questionnaire, that users independently complete. Survey respondents are subscribed to the service and are paid by the commissioning company. The company (CSA Research, a specialized market research and opinion survey company), as owner of the sample, takes care that it respects scientific criteria and that the sample reproduces the same compositions of the population strata. The sample is generally used to survey shared-interest opinions, political polls, national trends and customs. Proportional shares are respected, and the sample is stratified according to the following variables: age, gender, geographic area, educational degree and profession.
The national sample questionnaire surveyed the opinions of 1,500 respondents and was administered in the same period of the 2021 CATI survey.
The national sample is built under different criteria due to the different nature of interviewees selection, and it is used only as a term of comparison (see section 4.1.3).

4. Results and discussion

The principal results of the three surveys are presented in two paragraphs: Tsunami risk perception and Knowledge about tsunami.
The map below (figure 2) shows the geographical positions of the coastal areas where the survey was conducted (by region) and the seas surrounding Italy.

Figure 2. (Maps Data modified from: Google Maps, @2022). Map of surveyed Italian coasts and corresponding seas

4.1 Tsunami risk Perception

The risk perception is preliminary calculated considering the item Q13 "*In the Mediterranean Sea the occurrence of a tsunami is…*?" and Q16 "*Do you think that the coast of your municipality could be hit by a tsunami*?".

Survey data show that tsunami risk perception differs in relation to the seaside.

Commentato [LC2]: Thanks, we specified this in the graph description below, lines 287-290.

Figure 3 shows tsunami risk perception for events in the Mediterranean divided by respondents' coastal seaside.
In general, around 40% of the interviewed believe that a tsunami is likely to occur in the Mediterranean, except for the Adriatic Sea where the percentage is around 30%. Even more evident is the difference between Adriatic and other seas if we look at the respondents to the "unlikeness" of such event: more than 60% in the Adriatic vs. ~20% of Tyrrhenian, Strait of Sicily, Sardinian Sea and channel. Midway we find the Ionian Sea (43%), probably due to a mix between regions with memory of the 1908 event (Calabria and Eastern Sicily) and the Adriatic coasts of Apulia, where most recent tsunamis date back to the 18th century (Cerase et al., 2019).
If we look to the response values of "neither likely nor unlikely" we found high percentages of around 40% for all coasts except Ionian (12%) and Adriatic (9%). These high percentages are probably also associated with a low tsunami knowledge, especially if contextualized to the Mediterranean Sea, by the population.

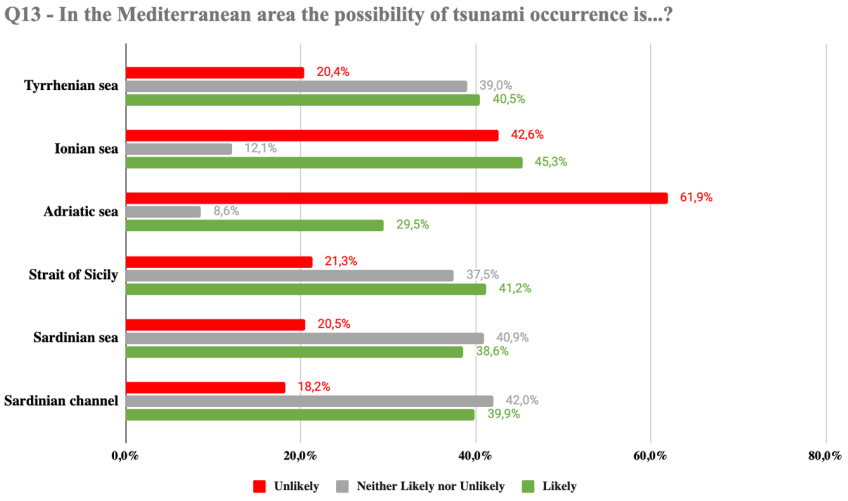

Figure 3. - Q13 - Tsunami risk perception in the Mediterranean sea by coastal regions

Figure 4 shows the distribution of answers to the specific question about the likelihood of a tsunami hitting the respondents' municipalities. The sample from the Ionian and Tyrrhenian sides seem to have a higher tsunami risk perception (49.6% and 45.2%, respectively). Differently, in the Adriatic coast municipalities, respondents have a lower perception of

tsunami risk, as for the previous question (figure 3). In fact, only 33% of them believe that their municipality may be affected by a tsunami, and 56.5% believe it will not.

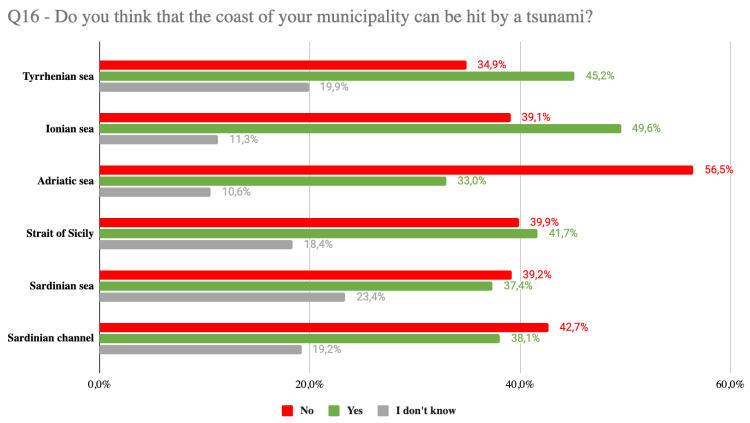

Figure 4. - Q16 - Tsunami risk perception in respondents' municipalities by sea areas

In the three-stage survey sample (n = 5,842), no significant variations are observed for the tsunami risk perception in relation to the gender of the respondents.

More significant differences emerge in relation to educational degrees. The sample with low educational degree showed more uncertainty in responses associated with the "*I don't know*" modality (23.4% and 23.1%, respectively, versus 11.2% of those with high educational degrees and 15% of those with medium educational degrees); a higher educational degree is correlated with a significantly higher tsunami risk perception (48.2%) compared to 37.9% for those with a lower educational degree.
The graph in figure 5 - reporting the tsunami risk perception in municipalities according to the numbers of generations of residence in the area - shows an interesting finding. In fact, risk perception is highest at 51,4% for the third generation (*my grandparents lived there*), whereas the average response rate for other generations is about 40%. These findings are consistent with recent studies based on an interdisciplinary historical-anthropological approach (e.g., Garnier and Lahournat, 2022). Indeed, these studies highlight the role of memory transmission of past disasters, more generally cultural memory, as an effective tool for DRR (Brokensha et al., 1980; Fernando, 2003; Gregg et al., 2006; Cohen, 2011; Sutton et al., 2021).

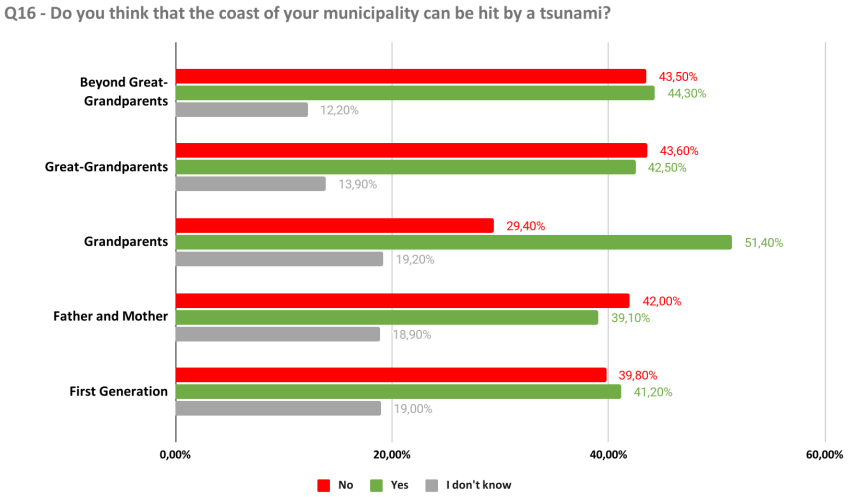

Figure 5. Q-16 - Tsunami risk perception in municipalities according to the numbers of generations of residence in the area.

4.1.1 Tsunami risk perception in surveyed regions

This subsection moves from the results of the paper by Cerase et al. (2019) where a significant difference in tsunami risk perception between Apulia and Calabria was found, despite the comparable, high tsunami hazard of the two regions (Basili et al., 2021). In the first region only 30% of respondents think their region could be hit by a tsunami and 57.5% think it could not, whereas the results for Calabria are very different, with more than 66% yes and 25% no (figure 6).

In order to verify the perception of other regions' inhabitants, we have compared the answers to the same question (Q16) related to the regions investigated in the second and third survey phases.

The graph below (figure 6) shows the percentages of responses collected for Q16 question for all the regions. The results show a strong heterogeneity among different regions, with the aforementioned Calabria and Apulia as end-members of risk perception. Molise, adjacent to Apulia in the Adriatic Sea, is on the low perception side with slightly higher values than this latter (40% yes, 53% no). Basilicata, with a few municipalities facing on both the Ionian and the Tyrrhenian coasts, has a slightly higher perception, with 44% yes and 48% no. Moving to the Central Tyrrhenian Sea, Latium and Sardinia show equal distributions of yes and no with a large number of "*I don't know*" (40, 40, and 20, respectively). Historical catalogs do not report relevant tsunamis for these two regions. Southern Tyrrhenian regions (Campania and Sicily) exhibit higher risk perception (48% and 46% yes, 36% and 33% no, respectively), even if not as high as Calabria. This can be explained with the presence of known tsunamis (as the 1908 event) or known potential tsunami sources, as active volcanoes of the Neapolitan area and in the Southern Tyrrhenian).

These results are consistent with the similar study, by Gravina et al. (2019). In that case, inhabitants from southern Italian regions facing the Tyrrhenian Sea were asked: "*Do you*

consider to be actively exposed to a tsunami risk?". 21% of interviewees answered *"highly"*, more than 42% *"quite"* and over 30% *"low"*. Nonresponses were 9%.
In addition, these regions, including Calabria, are highly seismically active, and people experienced frequent and even strong earthquakes. The traces of these events, present in the territory, are likely to rise people' s memory from generation to generation.

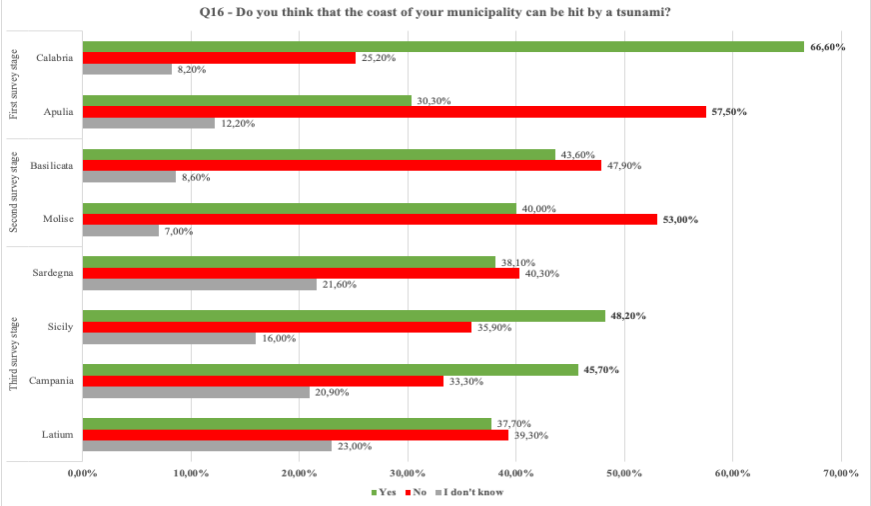

Figure 6. - Q16 - Tsunami risk perception in respondent's municipalities according to the regions.

4.1.2 Tsunami risk perception in metropolitan area and seaside

We started from the research hypothesis that the perception of tsunami risk could be different between the inhabitants of metropolitan cities and those residing in the municipalities of the relative coast. In our opinion, this comparison is particularly relevant for metropolitan cities in which the exposed value (in terms of human lives, industries and infrastructures) is considerably higher than the adjacent, less populated coasts.
The following graphs (figures 7-11) show the risk perception surveyed in coastal metropolitan cities (Rome, Napoli, Bari, Reggio Calabria and Catania) in relation to the risk perception of the seaside on which the city lies (table 2).

Region	Latium	Campania	Apulia	Calabria	Sicily
Metropolitan coastal city	**Rome**	**Naples**	**Bari**	**Reggio Calabria**	**Catania**
Sub demographic areas	6	5	2	5	2
Total municipalities	121	92	41	97	58
Total residents	4,342,000	4,250,000	1,261,000	549,000	1,068,000
Metropolitan city respondent	**824**	**938**	**169**	**134**	**155**
Seaside respondent	**3201**	**3201**	**549**	**910(Ionian) 3201(Tyrrhenian)**	**910**

Table 2. Sample size data by metropolitan areas and seaside (Source ISTAT, 2022. Database accessed on 07/2022)

To prevent statistical bias, the data for each individual metropolitan city were removed from the coastal data on which the city is located. We also carried out the T-test for independent samples from which a significant difference between the averages of the two samples (metropolitan cities and coastal area) were found. We used the test to indicate the sample statistical uniformity and comparability.
The graph in figure 7 shows the comparison between the sample of the Metropolitan city of Rome and the relative Tyrrhenian coastal area. In the case of the metropolitan city of Rome it is important to remember that Rome (2.7 million inhabitants) cannot be considered entirely a coastal city, even if some densely populated districts (like Ostia, with its 231,000 inhabitants) are entirely located on the seaside.
This is probably the reason why the average of the tsunami risk perception in Rome (figure 7) seems to be lower than the Tyrrhenian. Indeed, only 36.3% of the respondents believe that a tsunami may hit their municipality, versus the 48,2% of respondents living in the Tyrrhenian seaside.

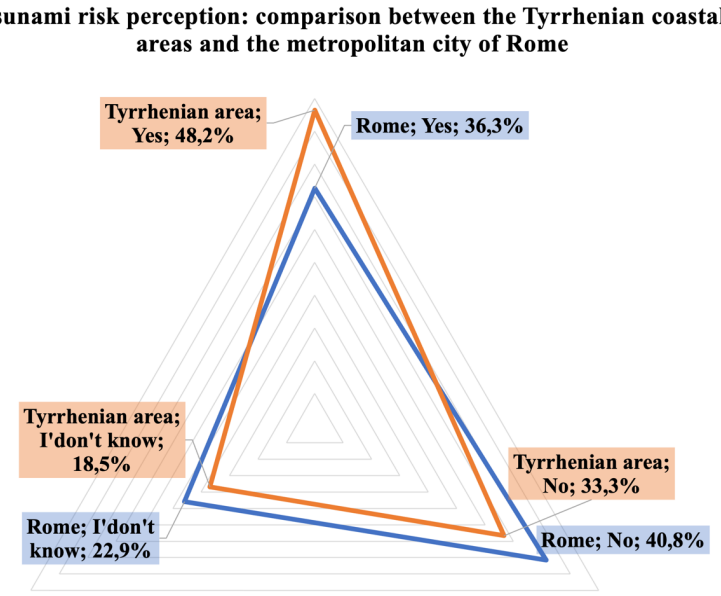

Figure 7. Tsunami risk perception: comparison between the Tyrrhenian coastal area and the metropolitan city of Rome. (Q-16. Do you think that the coast of your municipality could be hit by a tsunami?)

Tsunami risk perception in the Naples metropolitan city (figure 8) is almost the same than the average surveyed on the Tyrrhenian side. 47.2 % of respondents said that a tsunami could hit the coasts of their municipality compared to the Tyrrhenian area average, which - excluding the metropolitan city of Naples - has a value of 44.9 %. In this town 31.8% of respondents believe that a tsunami is unlikely to hit their municipality's coast, and 21% say they don't know the answer.
These data are consistent with the seaside average and it diverges from the starting hypothesis.

These data could be related to multi-hazard variables that lead the municipalities' residents to express a greater risk perception due to the presence of the Vesuvius volcano, the seismic memory of the 1980 Irpinia earthquake, and the frequent bradiseisms and micro-earthquakes that occur in the Neapolitan area (i.e., in the Phlegrean Fields). Traces of these events are also found in the literature, such as the case of the tsunami in 1345 AD, documented by the Italian famous writer Francesco Petrarca in his "*Letters on Familiar Matters*" (Bernardo and Petrarca, 1985), and recently described in Rosi et al. (2019).
Moreover, the city of Naples and the coastal municipalities of its hinterland, have high exposure due to civil settlements and industrial complexes including some Major Accident Hazard Industries (Tinti and Armigliato, 2003; De Pippo et al., 2008; Grezio et al., 2012) that are located on the coast. Last but not least, the metropolitan city of Naples has one of the highest coastal population densities in Europe, with concentrations ranging between 500 and 2,500 inhabitants/km^2(ISTAT, 2020).

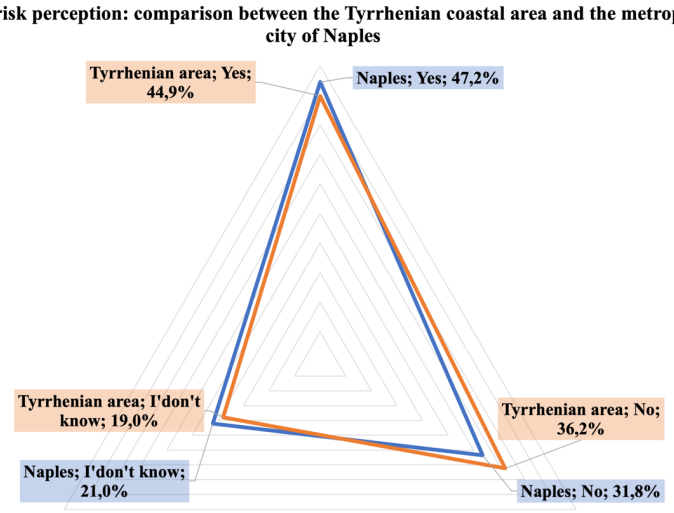

Figure 8. Tsunami risk perception(Q-16): comparison between the Tyrrhenian coastal area and the metropolitan city of Naples.

The average risk perception for the metropolitan city of Bari is low (figure 9), in line with the Adriatic coast. In fact, we observe that only 34.3 % of respondents believe that a tsunami could hit their municipality, versus 32.4 % of those residing in municipalities on the Adriatic coast. We also observe that 54.4% of respondents say a tsunami could not hit their coastal municipality, compared to 57.4% of the average of those living in coastal municipalities on the same seaside.
The perception results appear to be low compared with the estimated hazard for the southern Adriatic coast and Bari metropolitan city, which is medium/high (Basili, et al., 2021). The estimated hazard takes into account the strong earthquakes occurring along the Hellenic arc, able to generate tsunamis that would hit the Adriatic coasts including Bari. The low tsunami risk perception may also be influenced by the absence of recent tsunami events (Maramai et al., 2019) as already noted in Cerase et al. (2019).

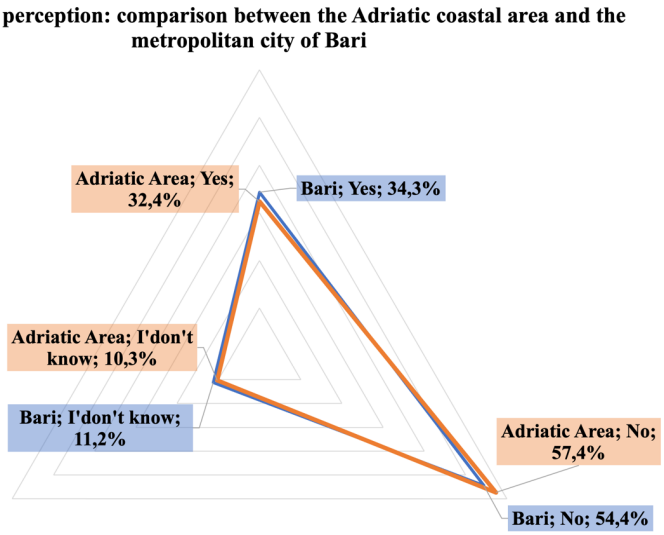

Figure 9. Tsunami risk perception (Q-16): comparison between the Adriatic coastal area and the metropolitan city of Bari

The tsunami risk perception in the metropolitan city of Reggio Calabria is on average high (figure 10). The graph shows that 70.9% of respondents believe that the city may be hit by a tsunami compared to the average of 46.5% of respondents living in the Ionian sides' remaining municipalities and 45% of those living in the Tyrrhenian sides' municipalities. Furthermore, data analysis shows that only 8.9% of respondents answered "*don't know*" to the specific question. This percentage could indicate that residents of the metropolitan city of Reggio Calabria have a greater tsunami risk knowledge of their area, compared to the other metropolitan cities considered in the analysis. The high tsunami risk perception is likely related to the 1908 tsunami, which had a strong impact on the territory, causing widespread damage and about 2,000 casualties (attributed to the tsunami), which still today holds a high media echo, currently in resident's memory. The same regions were also struck by a tsunami in 1783 that, according to historical sources, caused about 1,500 casualties (in addition to the over 25,000 caused by the earthquake) (Sarconi, 1784; Vivenzio 1788); and in 1905 when sea level changes were also recorded by tide gauges in Naples and Civitavecchia (about 500 km away).

In addition, Reggio Calabria residents' tsunami risk perception is in line with the high tsunami hazard estimated for the area (Basili et al., 2021).

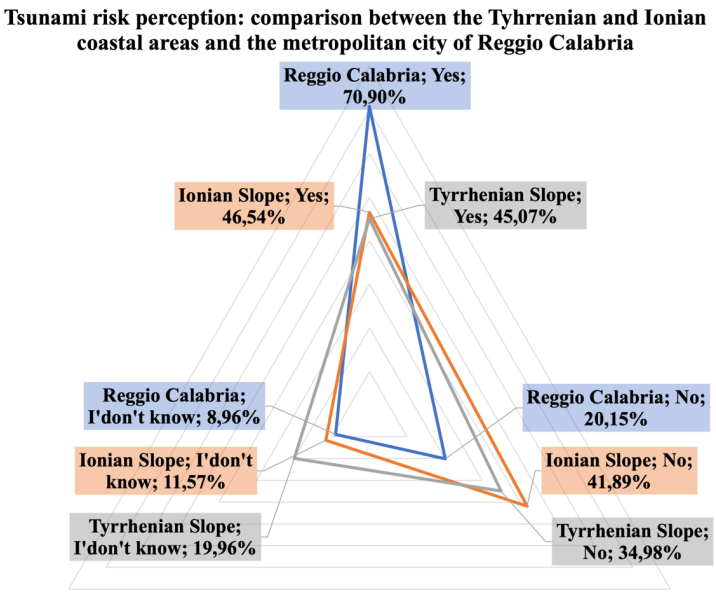

Figure 10. Tsunami risk perception(Q-16): comparison between the Tyrrhenian and Ionian coastal area and the metropolitan city of Reggio Calabria

The tsunami risk perception in Catania metropolitan city (figure 11) is slightly higher (49,7%) than the risk perception of respondents of the Ionian coastal area (45,8%). Only 11,6% of the respondents answered *"I don't know"*, in line with the responses from the other coastal areas municipalities. The percentage of tsunami risk perception in Catania, is probably associated with the presence of easily recognized hazards (e.g., volcanic risk and ash management due to the close Etna volcano, frequent earthquake shaking, etc.). In addition, industrial complexes and refineries along the coast increase the exposed value, and possibly the risk perception. Not least, the tsunami hazard (Basili et al., 2021) in the Catania area is quite high, due to both local and distant tsunamis.

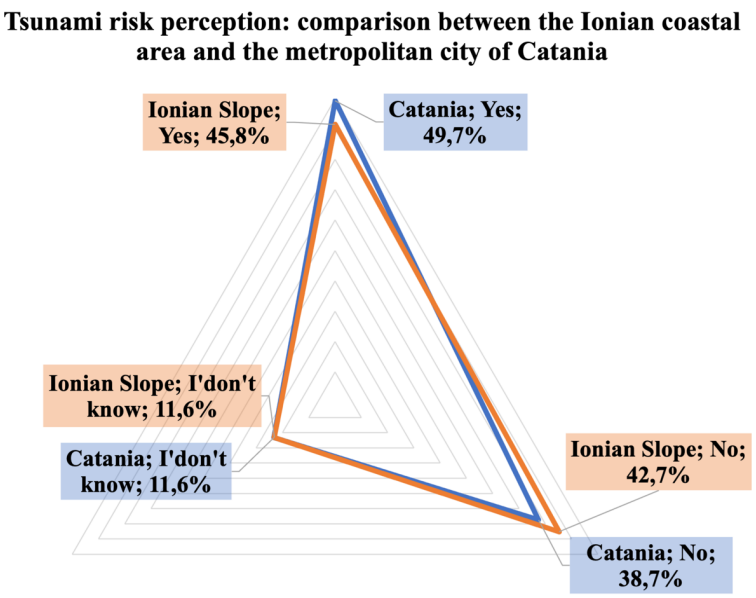

Figure 11. Tsunami risk perception (Q-16): comparison between the Ionian coastal area and the metropolitan city of Catania

Comparison among metropolitan cities (figure 12) shows a higher tsunami risk perception in Reggio Calabria, Catania, and Naples. These cities, throughout history, have been repeatedly affected by disruptive natural events including strong earthquakes, volcanic eruptions and tsunamis. The difference in risk perception between metropolitan areas and coastal areas remains the subject of further study. Bari metropolitan city has a low tsunami risk perception even though it is located in a stretch of coastline where tsunami hazard is considered medium/high. This could be associated with events that occurred in the distant past and the low frequency of earthquakes occurrence.

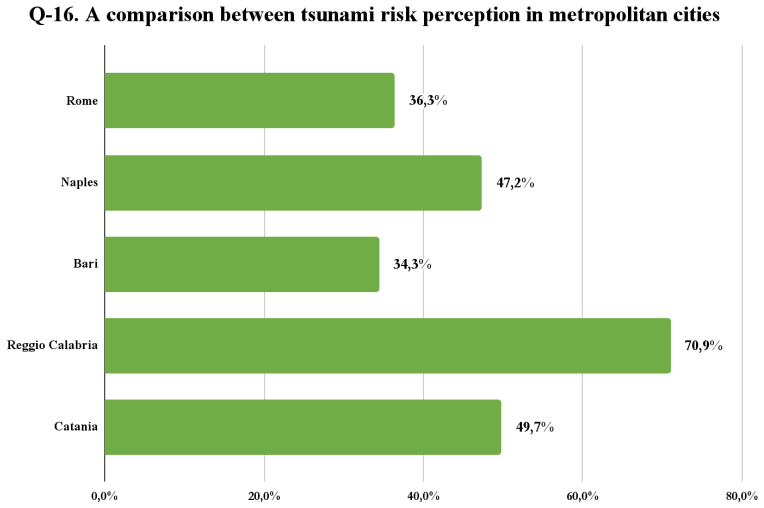

Figure 12. Tsunami risk perception (Q-16): comparison between the metropolitan cities ("yes" percentages answer).

4.1.3 Tsunami risk perception: comparison with a national sample

In this section, we compare the tsunami risk perception for events in the Mediterranean area (surveyed in question Q-13) among the whole coastal population described above, and a national population sample (National Sample survey n = 1,500). From the graph (figure 13), it can be seen that risk perception is higher in coastal communities (39.4%, CATI survey) and lower in the national average (19.2% National Sample survey). Minor variations can be observed in the other response modes. A difference of 13% also emerges in the central mode "*Neither likely nor unlikely*" from which low tsunami knowledge is assumed.
The National Sample survey becomes of primary relevance to also investigate the risk perception of the population not living in coastal areas who might face this risk in a summer vacation context even in non-national territories. Moreover, these data can be considered representative of the national mean related to the tsunami risk perception and may be used for comparison with data related to the same specific groups of population living on the coasts.

This result is not surprising, considering the lower familiarity of non-coastal inhabitants with sea activities - and hazards - compared to coastal cities residents. Also, we should consider that the tsunami risk for people spending for instance a two-week's vacation in a seaside location is statistically much lower compared to the risk to which a coastal resident is exposed. We anticipate that this result strongly suggests the need for a communication effort specifically oriented to tourists.

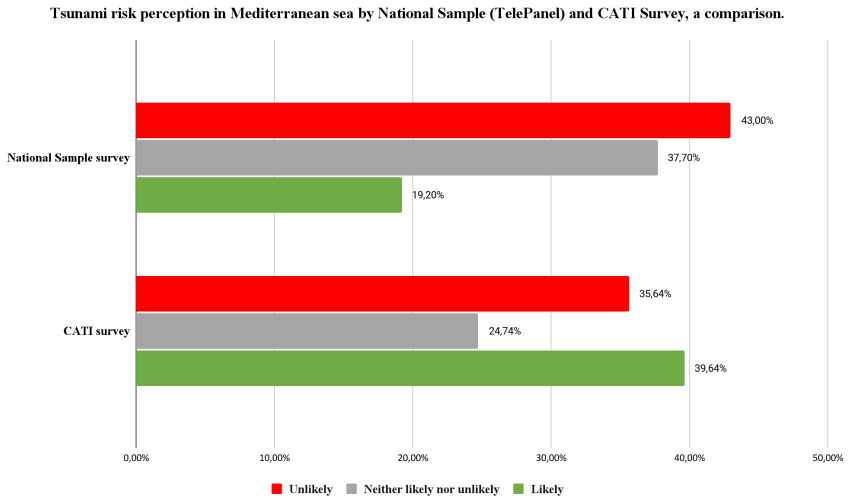

Figure 13: Tsunami risk perception in Mediterranean Sea by National Sample and CATI Survey, a comparison.

4.2 Tsunami Knowledge

4.2.1 Phenomenon description: elicitations of the terms tsunami and maremoto

In order to explore tsunami people understanding, we considered qualitative attributes as relevant indicators of phenomena mental representation and related effects. The first step aims to explore the differences between the Japanese word "*tsunami*" (literally harbour wave), broadly used in the international scientific community, and the word "*maremoto*" (literally seaquake), being a common alternative in colloquial Italian language. The overall results of this research confirm the different meanings attributed to these two terms by respondents.

Figure 14 shows that the largest part of the sample shows greater familiarity with the term "tsunami" (57%) while "maremoto" drops by several percentage points (43%). The word "tsunami" seems to sound more familiar for those who have higher education levels (66%) and are below 65 years old. Some interesting differences regarding the usefulness of the two terms are related to local characteristics and will be further investigated. For example, in Reggio Calabria metropolitan city interviewees generally use the term maremoto to identify the phenomenon (57%) whereas in Naples the term tsunami is more familiar (63%).

We could hypothesize that past events differently shape the way the phenomenon is acknowledged and understood, as culture provides different resources to address these events, where traditional environmental knowledge plays a prominent role along with scientific communication. These aspects are reflected in social representations (Moscovici, 1961) as well as in language being used to express such representations (Moscovici, 1976).

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Data in figure 14 show that the word "tsunami" is mostly associated with *big wave* (56%), *earthquake* (54%) and *sea storm* (34%), and in a more detached position *inundation* (26%), *flooding* (16%) and *sea withdrawal* (13%). Instead, the word "maremoto" is first associated with *earthquake* (57%), then with *sea storms* (40%) and *big wave* (37%). *Inundation* (23%) and *flooding* (18%) are still present along with *rough sea* (17%).

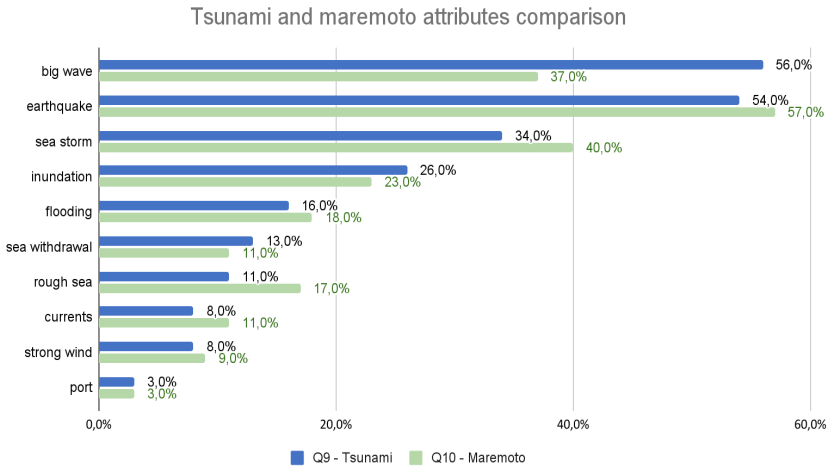

Figure 14: Tsunami and maremoto attributes comparison

4.2.2 - Knowledge about causes of tsunamis

With regard to the alleged causes of tsunamis, they are generally attributed correctly to earthquakes: 74% as the main cause, then to volcanic eruptions (44%), in agreement with the most frequent tsunami causes worldwide (NCEI/WDS, 2022) in the Mediterranean (Maramai et al., 2014) and in Italy, where 68% of observed or recorded tsunamis were caused by earthquakes and about 16% by volcanoes (Vesuvius and volcanoes of the Aeolian Islands) (Maramai et al., 2021).

In general, it is observed that tsunami knowledge is not directly related to the gender and interviewees distribution but directly increases with educational degree and decreases with age (young, highly educated people under 50 years old are best informed).

Tsunamis are also associated by respondents with meteorological phenomena. In general terms this is somehow overestimated, but we know that meteotsunamis are rather frequent in the Mediterranean, especially in the Adriatic Sea (Šepić et al., 2009; Vilibić et al., 2009; Maramai et al., 2022). However, it is possible that people confuse sea storms with (meteo)tsunamis. To verify this, we carried out a bivariate analysis that can provide some clues for this belief. Indeed, data highlight higher percentages for those who live in municipalities overlooking the Sea of Sardinia, as well as the Channel of Sardinia, both frequently swept by strong winds of *Maestrale*, which can locally originate sea storms with waves several meters high.

We also note that weather conditions are most frequently mentioned by people with low education levels (22%) versus 15% of the sample with high educational level.

Furthermore, landslides are properly indicated as a possible tsunami caused by 14,8% of respondents, as well as meteorites and space objects. A similar question, about tsunami risk perception induced by rock landslides, was asked in the survey conducted in Norway during the ASTARTE project by Goeldner-Gianella (2017). In Norway, respondents correctly show high tsunami risk perception induced by rock landslides. This result is mainly due to the frequency of rock collapses occurring locally, and to citizens' trust in local institutions for how tsunami risk is managed and how information is disseminated (Goldner Gianella et al., 2017).

4.2.3 - Knowledge about tsunami effects

Knowledge about tsunami effects are investigated by Q22 (*Try to figure out the effects of a tsunami / tsunami on the coasts of your region. How far do you agree with the following statements?*) Results show that in general, people are well aware about tsunami possible worst effects on the coasts of their region. In particular, deaths and serious injuries are recalled by 93,9% of the sample; damages to houses, buildings and infrastructures by 93.1%, and negative impacts on economy and occupation and on economy are both indicated by 89,4%. Worth to say that despite high rates of knowledge about tsunami possible impacts, women, most educated people, and people aged up to 65 years show slightly higher percentages, as well as the inhabitants of the municipalities included in the area hit by the 1908 Messina Strait tsunami. As to resume, these kinds of effects are well known and present to interviewees.

The data also show a catastrophic representation of tsunami effects that does not correspond to the expected effects on the Italian coasts where moderate-sized tsunamis are more likely to occur. This scenario probably comes from the diffusion of the catastrophic images of the tsunamis that occurred in Sumatra in 2004 and in Japan in 2011, widely conveyed by television and social media. Given that macro-effects of a tsunami are well recognized and understood, smaller effects at local and individual level seem to appear unfamiliar to respondents.

Commentato [LC3]: Ref. - According to my opinion tis is very important, because I believe that this "misunderstanding (i.e. a tsunami looks like the waves I have seen in the TV)" is one of the main factors that makes people in the Mediterranean believe that tsunamis cannot occur in this area.

Authors: yes, we totally agree and and we are deepening this also to understand what intervention margins there may be in risk communication.

Indeed, data show that large coastal flooding is acknowledged by 83% of the interviewed and sea withdrawal by 77%, and the possibility that a small tsunami might drag an adult into the sea is known by 75% (Q23). Only 24% of respondents think that fleeing to the beach after a strong earthquake is an appropriate behavior. The question about the possibility that a large tsunami with waves up to 20 meters may occur in the Mediterranean Sea raises some concerns, as only 46% of the overall sample considers it as a real possibility. Cross-tables highlight some unexpected surprises, such as higher rates of youngsters (31%) and women (27%) who consider fleeing to the beach a proper response to a massive earthquake.

4.2.4 - Data on the sources information

Data on the sources of information being used by the interviewees provide a relevant framework to address and improve tsunami risk communication. As for the previous paper, we have decided to group different sources into homogeneous categories. Data provide a clear indication on the central role of television, that is indicated as an information source by almost 90% of the sample. More in detail, TV news reaches 83% of respondents and documentaries or scientific channels reach 23%. Other traditional broadcast media, considered as a unique category including newspapers, books, radio and movies, are found to reach 58% of the public. Considering disaggregate penetration rates, newspapers were

mentioned by 35%, books by 19%, movies by 12% and finally radio had 8%. Surprisingly enough, the whole internet sources show a penetration rate of about 18% and interpersonal sources such as friends, relatives and neighbors weigh for 5%.

As noticed in the first step of the research, the impact of institutional and scientific sources appears to be a problematic issue urging the development of a proper and effective risk communication strategy, since their overall penetration rate is a mere 3,5%. More in detail, single rates are about 2% for the Civil Protection, 1,6% for Universities and Research Institutions and barely a 1% for local administrative entities such as the Region, the Province and the Municipalities. The residual category, other, has been mentioned by only 35 people, corresponding to 0,6%. This suggests that a strong effort is needed for institutional parties to fill this gap, through widespread and comprehensive dissemination of information (including info on evacuation routes and procedures) by using state-of-the-art communication channels.

Of course, data deserve further analysis by means of data reduction procedures, aimed at aggregating variables into new indicators and producing synthetic more effective understanding of the considered phenomena.

5. Discussion and conclusive remarks

The three surveys on tsunami risk perception, conducted between 2018 and 2021, started from the necessity to study and understand the level of knowledge of tsunami risk and the awareness of Italian citizens living in or visiting coastal areas exposed to tsunami hazard.
To date, these surveys represent a relevant sample of the Italian population, both for the number of interviewees and for the adopted methodology (5,842 CATI interviews carried out on over 6000 km of coastline with moderate to very high tsunami hazard, plus a nation-wide "telepanel" sample representative of the whole Italian population).

The main results show that the tsunami risk perception varies significantly according to the coastal region. In particular, regions in the Adriatic (Apulia, Molise) show very low levels of risk perception compared to Calabria, Sicily and Campania, both on the Ionian and the Tyrrhenian seaside. Latium and Sardinia lie in the middle, with equal numbers of people thinking that a tsunami could hit their region.
Educational degree affects tsunami risk perception indeed: the higher the educational degree, the higher the tsunami risk perception.
On the contrary, data analyses show that tsunami risk perception is not influenced by either gender or age. A slight difference is observed in the middle age group in which interviews of 35-49 years appear to have a slightly higher perception. Elderly people show the lowest frequency percentage in the response modality *"I don't know"* associated with low tsunami risk perception.

These data are consistent with several studies on local cultures, showing how communities that have previously experienced disasters are more likely to develop better resilience and preparedness (Dekens, 2007) to these calamitous events. Such knowledge, which differs from scientific knowledge (Flavier et al., 1995), is associated with the historical memory of past experiences learned and transmitted through rituals, traditions, narratives and folk songs (e.g. Smong Song in Simeulue Island) (McAdoo et al., 2006; Rahman et al., 2017; Rahman et al., 2018; Sutton et al., 2021) and defined in a different way as: "*local knowledge*", "*traditional knowledge*", *"indigenous technical knowledge", "peasants knowledge", "traditional environmental knowledge" and "folk knowledge"* (Sillitoe, 1998; Mercer et al., 2007; Mercer et al., 2012).
Memories of previous disasters both inform people's knowledge of their environment and vulnerability and also influence their risk interpretation and response to future disasters (Arunotai, 2008). Collective memory, relying on oral tradition shared by a specific group, most commonly the family, tends to disappear with the death of the last eyewitness to the event (the three-generation limit). Cultural memory, supported by documents (such as newspapers, archives, images) and memorials as tangible signs for the community, ensures that disaster meanings and interpretations are recorded and transmitted from generation to generation. These forms of cultural memory, considered by Mercer et al. (2010) as an existing or acquired knowledge set by local communities, are born and maintained through the accumulation of experiences, social relations, community practices and institutions, and their transmission across generations.
Garnier and Lahournat's (2022) study highlights how Japan Stone Monuments, representing elements of both tangible and intangible culture for the population, demonstrate the existence of disaster memory and reflect a desire to commemorate and transmit significant past events to current and future generations. These findings highlight the importance of oral transmission between generations about tsunami risk and could be very useful for designing

effective information and communications activities about tsunami risk reduction (Spahn et al., 2010; Løvholt et al., 2014; Oktari et al., 2018; Sutton et al., 2020).

In this work, we also carried out a comparative analysis on tsunami risk perception between the metropolitan areas and the respective coasts (see paragraph 4.1.1), starting from the hypothesis that risk perception could be different among the population residing in a large city and the population of small municipalities distributed along the seaside. The territorial units analyzed were selected based on exposure (higher coastal population density or proximity of major urban settlements to the coast) and territorial vulnerability (high concentration of anthropogenic activities such as industries or intensive tourism activities) according to ISTAT (Italian national statistical institute) data.

The goal of this comparison is both to highlight possible differences in perceptions associated with densely populated urban areas, and to provide a solid basis for targeted risk mitigation actions in specific contexts (for example to improve and better address the UNESCO Tsunami Ready Program (Valbonesi et al., 2019; Valbonesi, 2022).

The results indicate that in Reggio Calabria, Catania and Naples indeed there are significant differences in the tsunami risk perception compared to the relative seaside. This data is most evident in Reggio Calabria (71%) with a difference of over 25 percentage points compared to the Tyrrhenian (45%) and Ionian (46%) sides of the same region (Calabria).

The data continues to be significant, albeit less evident, for Catania (50%) and the Ionian seaside (46%) and for the city of Naples (47%) and the Tyrrhenian seaside (45%). It is useful to underline that the metropolitan city of Bari, despite being in a stretch of coast considered to be at high risk, has significantly lower values of perception of the tsunami risk (34%), in line with the data for the whole Adriatic coast (32%). Tsunami risk perception in the metropolitan area of Rome seems to be lower than on the Tyrrhenian coast. Probably this is because Rome cannot really be considered a coastal town because most of its over 3 million inhabitants live far from the sea. The presence within the metropolitan area of Rome of the town of Ostia, a very populous municipality (over 231,000 inhabitants) lying along the Tyrrhenian coast, is not enough to raise the overall risk perception of the capital. It would be interesting to deepen this aspect with specific analysis of the local residents, commuters and visitors. Given the city's proximity to the coast (about 20 km), it is also worth considering the large daily (as well as seasonal) tourist flows of the summer period.

The Telepanel data (n = 1,500), collected in the same time period as the third survey, deserve particular attention because they are a representative sample of the population at the national level, that means people predominantly living far from the seaside. Comparing the tsunami risk perception of the Telepanel with the surveys carried out on the coastal population, it emerges that the coastal population on average has a perception of risk significantly higher than the national average of about 20 percentage points. These data suggest that it is necessary to pay particular attention to the coastal touristic areas where every year millions of people spend their holidays. Providing information panels along the beaches and in the harbors, indicating evacuation routes and meeting points, establishing redundant alarm systems, are the main tools to be put in place to reduce the tsunami risk of both residents and tourists.

As for the knowledge of tsunamis, we started by considering the different associations linked to the two terms that are commonly used in the Italian language: tsunami and *maremoto*.

Results indicate that most of the sample is more familiar with the term tsunami (57%), particularly of those with a higher level of education (66%) and less familiar to people over 65 years old.

However, there are some differences that appear to be linked to local characteristics and which will be the subject of further investigation.
It is interesting to notice that the two terms are associated with different phenomena. For instance, the term tsunami is mostly related to the occurrence of a great destructive wave, while the word *maremoto* is more often related to the occurrence of an earthquake.

As for the knowledge of the causes that generate tsunamis, in general the sample correctly attributes the occurrence of a tsunami to earthquakes and secondarily to volcanic eruptions, in line with scientific knowledge. Furthermore, tsunami knowledge does not seem to be linked to the gender and the areas of residence of the interviewees but increases according to the educational degree and inversely to age (people with higher education degree and younger than 50 years old appear to be more informed).

Our data indicate that in general people are aware of the possible effects of tsunamis on their regions. However, this knowledge appears to be closely influenced by the media representation of the great tsunamis that occurred in Japan (2011) and Sumatra (2004). This type of media representation could turn out to be misleading with respect to the more modest phenomena that can be generated by smaller tsunamis, more frequently expected in the Italian coastal territory, but also capable of causing serious damage and victims.
However, the probability of a tsunami of significant size - such as the one occurred in 1908 in Southern Italy - is not entirely negligible.
Moreover, our data indicate that television continues to play a central role in conveying information relating to the tsunami risk, while the information role played by social media and the web appears to be still marginal. A particularly problematic aspect concerns the poor visibility of scientific institutions, civil protection and local authorities to be recognized by the interviewees as official sources of information on the tsunami risk.

Our results suggest that the loss of memory of past events affects the perception of risk by citizens and communities, making more difficult and even ineffective risk mitigation actions (see for example Kurita et al, 2007; Sugimoto et al. 2010; Arias et al., 2017 and Wei et al., 2017). Memory and recollections (such as commemorations of past events) are relevant for the development of risk mitigation strategies and to increase the population resilience. More specifically, a work of awareness raising aimed at attributing a sense and a meaning to the memory is needed in order to reduce the risk. We believe that the results of this study, although limited to central and southern Italy, can be used in other countries of the NEAM region and worldwide to orient communication strategies and risk reduction actions.

In the near future, given the large amount of data collected in the three surveys, we will focus on the creation of synthetic indexes for the perception and knowledge of tsunami risk.
We are also working to deepen the knowledge related to the cultural differences in the perception of risk which seem to be very influenced by the local culture of reference. We are confident that this will allow us to better explain the differences in perception and knowledge that the data show in the different sea areas (coastal sides) and metropolitan cities. Finally, our efforts will be focused on translating the results of risk perception analyzes into effective communication strategies for tsunami risk reduction. Not least, the 2018 pilot survey results - published in a previous paper by Cerase et al. (2019) - were already extensively used in developing and improving the CAT website content. Moreover, several relevant aspects of the study made it possible to better address approaches in risk awareness campaigns such as "Io Non Rischio" (a Civil Protection campaign) as well as undertaking dissemination

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campaigns aimed both to raise awareness and survey tsunami risk perception in schools (one of the Tsunami Ready program indicators).

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