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The INGV Tsunami Alert Centre: analysis of the responsibility profiles, procedures and risk communication issues

C. Valbonesi[1], A. Amato[2] and A. Cerase[2]

[1] *Dipartimento di Scienze Giuridiche, University of Florence, Italy*

[2] *Istituto Nazionale di Geofisica e Vulcanologia, Rome, Italy*

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ABSTRACT The Italian Tsunami Warning Centre (Centro Allerta Tsunami, CAT) of Istituto Nazionale di Geofisica e Vulcanologia (INGV) operates to issue tsunami alert messages both to the Italian Civil Protection system and to several countries of the Mediterranean. CAT-INGV started its activities as a candidate tsunami service provider in the framework of the ICG/NEAMTWS of IOC-UNESCO in 2013, to become operational in 2016. At national level, it operates since 2017 following the "SiAM" Prime Minister Directive, under the coordination of the Italian Civil Protection Department and together with ISPRA. In this paper we discuss the responsibilities of the CAT-INGV operators in the light of the Italian legal system, describing which are the critical aspects of the surveillance and issuance of the alerting messages, and trying to delineate the tools useful to limit legal problems for the operators in case of damaging events or false alarms.

Key words: tsunami, early warning, responsibility of scientists, science communication, ocean science.

1. Introduction

The Mediterranean region is characterized by high seismic hazard, due to the presence of many active faults. Some of these faults lie at sea or close to coastal areas, and are therefore potential tsunami sources. This is the case of the Hellenic, the Cyprus and possibly the Calabrian arcs, where a subduction process is underway, the coasts of northern Africa, the Messina Straits, eastern Sicily, and others. The catalogue of historical tsunamis in the Mediterranean demonstrates the presence of this hazard (Maramai *et al.*, 2014), that has been recently assessed by the TSUMAPS-NEAM project (Basili and TSUMAPS-NEAM TEAM, 2017). The position of Italy in the middle of the Mediterranean basin poses its coasts under tsunami risk both from local and distant sources, from Gibraltar to the easternmost Mediterranean region. Typical travel times for tsunamis originating in the Hellenic Arc are on the order of 40 to 60 minutes. They are higher (> 1 hour) for tsunamis generated near Cyprus and in the eastern Mediterranean, shorter (~25'-30') for the Ionian islands (Lefkada, Corfù, etc.). For local sources, such as the one relative to the 1908 earthquake and tsunami in the Messina Straits (Piatanesi *et al.*, 2008), the arrival times of the first tsunami wave are much shorter for the areas around the fault (less than 10 minutes), and increase as far as the distance from the fault increases.

The mentioned time ranges are such that a regional tsunami early warning system may be able to reduce significantly the risk, alerting the population located near the seashore.

After the tragic tsunami in Indonesia on 26 December 2004, in which over 250,000 lives were lost around the Indian Ocean region, the Intergovernmental Coordination Group for the Tsunami Early Warning and Mitigation System in the north-eastern Atlantic, the Mediterranean and connected seas (ICG/NEAMTWS) was formed. The Intergovernmental Oceanographic Commission of UNESCO (IOC-UNESCO) received a mandate from the international community to coordinate the establishment of the System during the course of several international and regional meetings, including the World Conference on Disaster Reduction (Kobe, Japan, 18 - 22 January 2005)

After some years of preparation, since 2013 the Istituto Nazionale di Geofisica e Vulcanologia (INGV) has endorsed the task of setting up a monitoring system for potentially tsunamigenic earthquakes in the Mediterranean, thus creating the Centro Allerta Tsunami (CAT) of INGV (CAT-INGV). CAT-INGV has started the monitoring and forecasting in October 2014, in a pre-operational way both at national level and in the NEAMTWS framework as "candidate Tsunami Service Provider". After an evaluation by a specific NEAMTWS commission, CAT-INGV has been accredited as an official Tsunami Service Provider in the fall of 2016. At national level, it started the operational activity on 1 January 2017. On February 2017, a national act (Directive of the Prime Minister, 2017) has established the whole Italian System for seismically induced Tsunamis, composed by the Italian National Department of Civil Protection (DPC, coordinator), the INGV and the Istituto Superiore per la Ricerca Ambientale (ISPRA).

2. The challenges of facing a "predictable" and rapidly changing risk

Dealing with natural hazards and the related issues unavoidably means confronting with uncertainty. The whole question may be effectively summarized by this statement "If the future were either predetermined or independent of present human activities, the term 'risk' would make no sense" (Renn, 1998). Along with other kinds of systemic risks, the potential threats posed by tsunamis to the environment, communities and human health are embedded within a particular economic, political and social context that also includes legal and organizational framework and can differently affect the way risks are handled, which in turn may both amplify or mitigate the extent of the threat (Renn and Klinke, 2004). Hence, any attempt to manage the risk posed by tsunamis entails the need to deal with different sources of uncertainty, arising from nature, science, law, policy-making, as well as societal response. Each of these elements should be properly assessed and considered within an integrated Risk Governance framework (Aven and Renn, 2010).

To date, all the tsunami-warning centres worldwide are focused on tsunamis induced by large earthquakes occurring at sea or near the coastline. This has two reasons: i) the predominance of seismically induced tsunamis (around 80% of the total); ii) the fact that these latter are the only ones that may be anticipated by recording and analysing the seismic waves, that travel much faster than tsunami waves, allowing a quick assessment of the earthquakes' characteristics, that are used to assess the tsunamigenic potential.

Typically, the first alert messages from the warning centres are issued after 10 to 20 minutes from the earthquake origin time (IOC-UNESCO, 2016). The need for the rapid determination of the seismic parameters introduces a critical element into the system. The faster the estimates (of

the hypocentral coordinates and magnitude), the higher the uncertainties associated with them. This implies that people operating in the warning centres are exposed to the risk of failures or errors.

The errors may be of several types. A) The first one is the risk of delivering a correct message (based on the correct estimates of the earthquake parameters) but in a too long time. B) The second one is the issuance of an underestimated magnitude of the earthquake, leading to underestimated alert levels. C) The third case is in the event of an overestimate of the earthquake size, after which the computed alert levels are higher than what is observed (in case the tsunami does not occur, it will bring to a false alarm).

In addition, since the alert levels on the coast are estimated based on some a priori assumptions relating the earthquake parameters to the tsunami size[1], it may happen that even if the former are well calculated, the alert levels may be wrong.

For what described above, it is evident the need for a clear regulation of the procedures and a careful study of the responsibilities of all the operators of the CAT-INGV.

3. The INGV Tsunami Alert Centre (CAT) between risk and science

The complex system of the tsunami risk management includes the INGV's Tsunami Alert Centre, that is in charge of issuing the first alert, through specific personnel on shift. Such a delicate task involves several aspects of responsibility that can be more easily understood through an examination of two fundamental profiles: a) the peculiar characteristics of risk; b) the operational structure of the subjects responsible for managing it.

The meaning of tsunamigenic risk that concerns our subject coincides with the notion explained in the Directive of the Prime Minister, published on 5 June 2017.

This risk originates from the seismic events occurring in the Mediterranean Sea. If these events are strong and shallow, they may generate a variation in sea level that can spread and impact on the coasts of our peninsula. As established by the Directive, "CAT is activated for seismic events of estimated magnitude equal to or greater than 5.5 that occur exclusively in its area of competence" (i. e. the entire Mediterranean basin) defined in Annex 1 of the Directive.

The aforementioned directive also specifies scientific methodologies and parameters to be adopted in order to ensure service operations. The subject is characterized by a heated debate: the epistemological picture of tsunamigenic risk is, in fact, deeply varied and sometimes contradictory.

The circumstance determines considerable criticality: the impossibility of identifying operational management procedures uniformly adopted by all the countries involved is associated with a peculiar nature of the tsunami risk. This, unlike seismic risk, can be somehow predicted. In fact, a wide range of cases shows us how, from the occurrence of the tsunamigenic earthquake

1 The current standard operational procedure at the CAT includes the adoption of a so-called Decision Matrix (DM), which relates the earthquake parameters (distance from the coast, depth, magnitude) to the alert levels predicted at local (within 100 km), regional (within 400 km) and basin-wide distance. The DM has been approved by a special committee of the ICG-NEAMTWS during the accreditation procedure of the CAT in the summer of 2016.

to the arrival of the waves on the coast, there might be time to alert the population that, if well prepared, can save itself and sometimes minimize the impact on infrastructure.

The predictability of the arrival of the tsunami waves and the consequences on people or things can be the basis of a criminal reproach for operators who have not properly managed the risk.

This triple uncertainty - of the scientific data that is reflected in the predictive risk - is also a source of considerable difficulty in determining responsibilities.

4. The definition of tasks and related responsibilities

The CAT Steering Committee is composed by seven members, each of them with a specific expertise and task. The respective tasks were defined by the INGV Board of Directors (CdA) resolution no. 322/2017 of 20 February 2017.

The INGV entrusted a number of researchers and technicians with the tsunami surveillance service. Their classification, for the purposes of our work, must be analysed on the basis of their functions. We therefore distinguish between CAT personnel on shift, CAT officers on call, and CAT Steering Committee members.

The resolution 322/2017 entrusts the management of the CAT service to INGV staff members who, on a voluntary basis, are called upon to carry out the surveillance shifts in the seismic room of the CAT- INGV headquarters in Rome.

The CAT workstation is monitored 7/7 H24 by subjects who have been duly trained, through a series of technical and scientific courses organized by the Directorial Board of CAT (CAT CD). These people are also required to follow the technical-scientific updating offered to them on an annual basis, and also to verification procedures to assess their knowledge and ability to perform the monitoring shifts.

CAT personnel on shift are central to the management of tsunamigenic risk: they are asked to verify the accuracy of the automatic locations and magnitudes of the earthquake; to examine the elaborations coming from specific software; to communicate the initial tsunami alert to the DPC (within 14 minutes at most); to take care of the evolution of the alert by updating or changing the typology of the messages (assisted in these phases by the officer on call).

The officer, according to the provisions of the CAT job descriptions and protocols, represents a leading figure in risk management. In fact, as also stated in his job description "the CAT officer, during the period of service, is responsible for the proper conduct of the tsunami alert shift".

Officers, who are also properly trained and kept constantly updated, are responsible for making choices based on a higher degree of discretion and scientific complexity.

During shift 7/7 H24, the officer will be called on to assist the personnel on shift in the phase following the issuance of the first message and until the end of an alert.

The CAT is managed by the members of the Steering Committee, who are entrusted with specific tasks of impulse, management and supervision. All together they are called to express a common policy during the periodic meetings and their activity is coordinated by the responsible of the Centre.

The framework highlights two different areas of competence from which different responsibilities derive. The members of the CAT-CD may be considered responsible for the consequences of strategic or scientific choices that result in incorrect investments or incorrect

directives. On the other hand, personnel on shift may be considered responsible for failing, lately or incorrectly sending the alert message. Finally, officers on call will be held liable for the harmful or dangerous consequences of incorrect choices taken in the phase of an ongoing alert.

The Italian legal system reacts very severely to active behaviour or omission that causes damage or endangers protected legal assets (life, health, environment, property) (Blaiotta, 2007).

The subject of our interest is, in particular, the response in Italian criminal law that is likely to be expressed in the crimes of manslaughter, culpable injuries and disaster caused by negligence.

The conditions for the existence of criminal liability are: a) the active or omitted behaviour of the agent, b) the existence of a causal link between the behaviour and the event; c) the guilt of the agent who, in our case, will assume the form of negligence.

The most critical profiles certainly subsist in the configuration of culpable liability (negligence), according to the art. 43 c.p. (Italian criminal law).

In order to have negligence, it is necessary to identify the precautionary rule that the operator had to observe and instead failed to comply with, contributing with his conduct to cause the event. When the precautionary rule is written (laws, regulations, orders, and disciplines) there is "specific negligence". When these rules are not written (negligence, imprudence, and malpractice) we will have "generic negligence". In any case, the judge, when assessing the liability, must always check what written or unwritten caution was to be applied at the time of the event and whether this rule was effective.

Unfortunately, jurisprudence in the medical field, in the area of criminal protection of work and in the context of natural disasters has shown that some judges, who are not very respectful to the rules of culpable reproach, convict the defendant applying *ex post* precautionary rules. It follows that culpable responsibility is often recognized because, after the event, there is always a tendency to create or detect an effective caution: *post hoc, ergo propter hoc*.

In this critical framework for all risk operators, the CAT, when became fully operational in January 2017, had a set of rules that could guide the operator in the proper management of risk, in the light of the best scientific knowledge. However, the CAT had not enough detailed guidelines and protocols that could constitute that set of valid and uniform disciplines to guide both the personnel on shift and the officer on duty during operations, and the judge, if he were called upon to assess the responsibility for an event.

The absence of this regulation therefore posed a problem not only in the physiological phase of ordinary risk management but also in the pathological phase, i.e. when it would be necessary to determine culpable responsibilities.

The CAT CD has therefore identified the current operational and technical rules most accredited by the scientific community and has transposed them into job description documents, guidelines, and operational protocols. This complex work aims not only to offer support for the CAT personnel, but also to allow the judge to assess the benchmark of best science and experience in the historical moment.

This codification effort, still in progress, is not expected to eliminate completely the margins of culpable reproach, but aims to standardise the "precautionary panorama" and introduce a consolidated scientific method into any process that may take place.

The complex path towards standardisation and the "codification" of culpable reproach is based on a number of basic assumptions which will be explained in the following paragraph.

5. In search of the scientific profiles of culpable reproach

For some years now, culpable reproach has been one of the favourite ground for the debate between scientific progress and safeguarding the health and integrity of assets which may be adversely affected.

The influence of risk on criminal law has changed the structures of culpable reproach, which has lost its constitutive pillars in favour of a more flexible and certainly more severe application (at least in Italy). The departure from the paradigm firmly anchored to a predetermined precautionary rule allows decisions based on precaution created ad hoc, anyway after the execution of a causally relevant conduct. The loss of the regulatory anchorage determines a deep uncertainty of the culpable reproach which, as the tragic events of the *Grandi Rischi* trial have taught us, is characterized today by a low attention to the scientific profile of caution[2] (see Amato *et al.*, 2015; Cocco *et al.*, 2015 among many others).

In order to become an objective and subjective prerequisite of responsibility, the causal link and precautionary rule must be based on a solid scientific ground (the best science and experience of the historical moment) aimed at establishing: 1) the correlations between conduct and event; 2) the validity of the *corpus* of rules, instrumental to the correct management of an allowed risk.

This requirement seems to have been disregarded even in the recent Supreme Court ruling on the *Grandi Rischi* trial, which highlights - in all its scope - this delicate balance between risk and culpable reproach, based on a previous decision of the Supreme Court taken about the mayor of Sarno[3] after the 1998 flooding event that killed 160 people.

The doctrine has correctly denounced the adverse effects that the risk paradigm has had on the criminal reprimand: "during the trial (the trial of first instance at the so-called *Grandi Rischi* Commission, Autors' Note), in front of the seismic risk materialized at a specific time and place, reference was made to the possibility of integrating omission guilt into the behaviour of those who did not recognize and publicize it, essentially assigning to risk a role not only necessary but also sufficient to attribute the culpable event of death and/or injury" (Militello, 2016).

Such a development would lead to a fundamental paradigm shift: the role of risk as a structural element of culpable reproach would be shifted from a real "criminal law of risk" whose trend "expresses itself, typical of a society of risk such as the present one, to move on to charges not based on the occurrence of the event, but which anticipate protection against the creation of a not allowed risk, especially when the value of the event is particularly high, for example for the number of persons involved" (Militello, 2016).

The search for instruments aimed at ensuring a more adequate reproach for the harmful event must once again start from the definition of a field of defined precautionary rules, expression of the best science and experience, updated and validated by national and international official Institutions.

The normative essence of the negligence is expressed in the necessity of its *hetero integration* through the precautionary rule that shapes *ex ante* the latitude of application.

Precautions for the management of a risk, allowed by the legal system, should constitute common ground for the expert, the scientist and the judge. Correlatively, there could be no room

2 Cass. pen. Sez. IV, 24 marzo 2016, n. 12478, in *DeJure*

3 Cass. pen. Sez. IV, 3 maggio 2010, n. 16761, in *DeJure*

for the recognition of a negligence used by the judges to attribute responsibility for events often unknown or difficult to dominate.

Anyway, we cannot deny the existence of generic guilt and we must take note of the current absence of national authorities responsible for the management and regulation of tsunamigenic risk. For these reasons it will be necessary to explore the Italian legal framework in order to find, by analogy, a discipline aimed at conferring a regulatory structure on the CAT-INGV (Leoncini, 1999; Mantovani, 2001; Stella 2003a, 2003b; Pulitanò, 2007; Perini, 2010; Marinucci, 2012; Gargani, 2015).

Two paradigms can be chosen: 1) the regulatory and jurisprudential apparatus relating to medical negligence; 2) the dictates of the *Grandi Rischi* Italian Supreme Court's judgment.

We move, precisely, from the words of the judgment of the Supreme Court which, urged by the accused's defence based also on the appropriateness of extending to other risk operators the discipline of culpable reproach provided by the Balduzzi Law, offers arguments of great value for the investigation that involves us today.

In order to better understand the Court's decisions, it is necessary to immediately reconstruct, albeit briefly, the particular discipline of culpable reproach in the medical field in Italian law, which has always been entrusted to the art. 2236 c.c. (Italian Civil Code): "if the service involves the solution of technical problems of special difficulty, the service provider (*prestatore d'opera* in the Italian Civil Code) shall not be liable for damages except in the event of gross negligence".

Art. 2236 c.c. (Italian Civil Code) now becomes, in Italian criminal law, a rule of experience that the judge can follow in order to assess the charge of malpractice, both when the professional is in an emergency situation and when the case involves the solution of technical problems of special difficulty.

The abnormal proportions assumed by the litigation in the field of medical negligence, together with the related need to limit the "defensive medicine", have suggested the legislator to introduce a specific statute of culpable reproach. After a long parliamentary debate, a first amendment was introduced by Law no. 189 of 8 November 2012, which, in its first nucleus of application, reads: "the practitioner of the healthcare profession who, in carrying out his activity, follows guidelines and good practices accredited by the scientific community does not respond criminally due to slight negligence". In this way, the law excludes from the area of criminal behaviour those characterized by compliance with both accredited guidelines/good practices and the slight degree of guilt (Caputo, 2012; Brusco, 2013; Cupelli, 2013; Pulitanò, 2013; Risicato, 2013; Valbonesi, 2013a, 2013b; Vallini, 2013).

In order to better understand the field of application of the law and, consequently, its potential transposition into our discipline, it is necessary to explain what is meant by guidelines and protocols.

If guidelines are defined as "a set of recommendations systematically developed on the basis of continuously updated and valid knowledge, drawn up in order to make a desired behaviour, appropriate and with a high standard of quality", the term protocol refers to the codification of a group of fulfillments performed in synchronous or diachronic sequence which becomes the norm when the parties involved establish its compulsory nature.

It has also been noted that "the expressions *guidelines and protocols* indicate both the implementing modalities of a certain activity and the document that formalizes these procedures". It follows that the guilt judgment will be based on the content profile of the

"procedural actions" and not on the formal one, that will be relevant only on the evidence level (Giunta, 2013a, 2013b, 2013c).

In the framework of the Balduzzi Law, an action complying with these provisions - even if a bad event does occur - may lead to the exclusion of reproach for negligence (with the exception of behaviours characterised by gross negligence).

The question is: what is meant by negligence (different from gross negligence)? The degree of negligence, in Italian Criminal Code, is an element evaluated by the judge in determining the penalty (art. 133 of the Criminal Code). A very different field! So, in the loss of the interpreter, the Supreme Court tried to offer a definition of "negligence" and "gross negligence". The judgment Cantore[4] enucleates some symptomatic elements to identify the existence of different fault coefficients: 1) the measure of the divergence between the conduct actually carried out and that which was to be expected on the basis of the precautionary rule which had to be followed ("it will be necessary to consider what has deviated from this rule"); 2) the adequacy of the subject to face the risk, that determines the *quantum* of due diligence and the amount of trust placed by the community on his work; 3) the *rationale* for the conduct: "Deep and inappropriate therapeutic treatment is less serious if carried out for an urgent reason"; 4) the predictability of the event.

At the time the Supreme Court's judgment was handed down, therefore, there was a particularly favourable statute of the culpable reproach reserved to the medical class.

As the Court points out, this *culpa specialis* certainly does not support a mere bureaucratic attitude, which consists in supine trust and blind observance of guidelines and best practices. The doctor must assess their relevance to the specific case because their application may even be contraindicated in that specific case. The provision, therefore, punishes as a fault both incorrect adherence to the guidelines and undue departure from these requirements.

In the opinion of many scholars, this autonomous statute, which is particularly in favour of criminal liability, can and must constitute a sure ground for a reflection on a general reconsideration of the culpable reproach for the entire category of risk operators.

By comparison with fractals, the Supreme Court highlights that some "procedural precautions" are "supervised" by technical regulations. Well, the violation of one of these rules "is likely to reverberate on the caution that all contain them" and at this point "one cannot doubt here the relationship with the event"[5].

The judges exhort not to create *empty* cautions but to give importance to rules full of technical aspects, which are modal, in fact. Rules that identify and explain which behaviour can prevent or content the unlikely event.

The process of strengthening the effectiveness and the codification of the caution, to which a different modulation of the culpable reproach is linked, seems to be the framework chosen today by the legislator who, with the Balduzzi Law, has begun to identify protocol rules with a real impeding effect of the event. These rules, whose observance excludes the possibility of being punishable for negligence, must be accredited by the international scientific community.

The creation of "protocol negligence", based on technical operational aspects fitted with a modal nature, represents a central model also in the management of tasks and in the assessment of responsibilities related to civil protection activities. Only guidelines and protocols can guarantee,

4 Cass. pen. sez. IV, 9 aprile 2013, n. 16237, in *DeJure*

5 Cass. pen. sez. IV, 9 aprile 2013, n. 16237, in *DeJure*

on the one hand, a certain and orderly approach to risk and, on the other hand, a valid activity to prevent its consequences.

The centrality of protocol cautions in the management of risks, related to medical activities, has recently been confirmed by the Gelli-Bianco Law (law n. 24/2017), which presents particularly complex and detailed contents (see among many others: Brusco, 2017; Centonze and Caputo, 2016; De Francesco, 2017; Palma, 2017; Risicato, 2017). The law highlights the importance of the protocol rules even in areas different from medical activity. These prescriptions represent an essential guideline for a correct disciplinary approach to tsunamigenic risk.

In this hermeneutical process we must start from a clear assumption: to date, the limitations on culpable reproach related to the observance of guidelines and good practices, according to Balduzzi and Gelli-Bianco laws, does not extend to other areas of permitted risk, and therefore not even to the activities of the CAT. Moreover, it must be clear that, even in the context of medical responsibility, there is also a wide-ranging debate on the role reserved to guidelines and protocols.

The jurisprudence explains that, although guidelines and protocols constitute a set of cautions suitable to guide both the operator's behaviour and the judge, *peritus peritorum*, even though they "are not able to offer pre-established legal standards. That is, they do not become precautionary rules according to the classic model of specific culpable reproach because: 1) on the one hand, the variety and different degree of qualification of the guidelines; 2) on the other hand, above all, their nature of guidance instruments". The decision is based on an irrefutable assumption: the heterogeneity of guidelines and protocols in the medical sciences does allow neither a uniform approach, nor the possibility of verifying this approach.

The changes introduced by the Gelli-Bianco Law allow us to envisage some significant modifications. It is still too early to say so, but it is possible that this law, introducing the obligation to collect, create and validate guidelines, allows the creation of a set of "public" caution. These institutional decisions could really become a precautionary rule, consubstantial to culpable reproach.

Despite these accredited and recognized rules cannot exhaust the precautionary panorama or constitute themselves a valid rule, regardless of the content profile, it is certain that the source and the rank which art. 5 of the Gelli-Bianco Law confer to them, allows us to enroll these cautions in the list of disciplines [art. 43 c.p. (Italian criminal law)].

And *quid iuris* for protocols? In fact, in the context of the new regulations, they can be assimilated to the "good practices" referred to in arts. 3, 5 and 6 of the Gelli-Bianco Law. The legislative provision, although not very clear, seems to give to good practices a lower rank than the guidelines because (in spite of the content profile of art. 3) it excludes them from the category of cautions "defined and published in accordance with the law". But protocols constitute a private training with a very high modal content and "in containing the risk factors inherent in the regulated activity" they carry out "a preventive function of the harmful events that materialize such risks" (Giunta, 2013c).

For this reason, they can become precautionary rules whose violation can be evaluated as a negligence. To see well, the complex panorama of protocols, cannot allow any automatism in excluding responsibility, especially where the protocol is no longer scientifically updated.

Therefore, as recently stated by the Supreme Court[6], the "guidelines have an orientation

6 Cass. pen. sez. IV, 20 aprile 2017, n. 28187 in www.cassazione.it.

content, make recommendations, and should be distinguished from more rigid and prescriptive training instruments, usually called protocols or checklists. They do not indicate an analytical, automatic succession of fulfillments, but only propose general directives, general instructions; and therefore they must be applied in concrete terms without automatic procedures, but in relation to the specific characteristics of the specific case".

The Court tells us, therefore, that there is a substantial difference between the guidelines, such as abstract instruments that may or may not integrate the culpable reproach, and protocols, whose meaningfulness and rigidity make it an instrument of standardization.

Therefore, we must be explicit: the CAT operator, who realizes that the protocol provided to him presents errors or is ineffective with the case is called to deal with, has the obligation not to apply it in order not to incur on a culpable reproach.

Drawing on the ranks of our considerations, we can therefore affirm that the synergy between: a) the rulings of the so-called *Grandi Rischi* judgment, which confers a general legitimization to protocol cautions in all areas of risk; b) the substantial regime of succession of integrative precautions for criminal reprimand which highlights, also at the jurisprudential level, a consubstantiality between secondary norms and culpable reprimand; c) the regulatory complex of the Gelli-Bianco law, leads to the recognition of the need to identify and codify a set of protocol-based precautionary rules that assist the performance of functions related to the CAT-INGV.

The codification of procedures, that assist the correct and shared management of risk, represents not only a duty towards "risk operator", but also an indispensable opportunity to involve institutions in the definition of technical scientific procedures for the management of tsunamigenic risk.

Since we are not able to fully borrow the rules governing the new statute of medical guilt, where compliance with the guidelines and protocols constitutes, under certain conditions, a cause for exclusion of negligence, we can nevertheless adopt the fundamental principles of the discipline used to define a scientifically impeccable set of rules, shared and updated, available to the operators who have to adapt to it, and (in case of damaging events) to the judge who can measure the conformity of the conduct kept to the prescriptions resulting from the best science and knowledge, pertinent to the specific case.

Evidence of having followed clear, scientific, shared, updated rules could represent a decisive possibility, for the operator, of excluding a specific fault.

Defence argument could be used above all for the hypotheses of generic guilt where documents correctly point out the scientific uncertainty that dominates the international debate on the various aspects of tsunamigenic risk, thus allowing a more limited assessment in terms of inexperience.

Let us, then, come to the analysis of the constitutive requirements that must contain guidelines and good practices (*rectius* protocols) in order to be able to rise to the rank of precautionary rules.

In the first place, the discipline of allowed risks imposes the creation of cautions with an exquisitely modal content: a caution is such only if it fully indicates the *an*, the *quando* and the *quomodo* (if, when and how) of the risk management.

Secondly, the rule must be effective in preventing the occurrence of the event that has occurred and not of a generic event. We must remember this, in spite of what has been affirmed by the majority jurisprudence, which almost always recognizes responsibility for a generic event of those that the precautionary rule wanted to avoid.

But we must not lose sight of the foundations governing the causality of guilt. The correlation

between precautionary rule and event must be very close and the subject will be verifiable for the only foreseeable harm that the precautionary rule aimed, effectively, to prevent or mitigate.

The possibility to avoid the event is nourished by the scientific validity of the assumptions that shape the rule: since there are some risks objectively not able to cope because of an unfinished technical-scientific path, it is necessary to verify that the scientific evidence of caution has a real effectiveness in preventing the event.

The lack of national institutions (such as authorities) responsible for the identification, definition and validation of scientific rules on the model of those described in the Gelli-Bianco Law, does not exempt us from reiterating some indefectible principles. The drafting of the guidelines and protocols must be carried out in accordance with the scientific and technical assumptions of the most authoritative national and international "scientific societies".

INGV represents, in Italy, the most important scientific authority in the field of tsunamigenic risk: it follows that the precautionary rules, even if they are the result of a necessary self-made process, must nevertheless be inspired by the standards dictated by the best science and experience in the international context. Moreover, these requirements will have to be examined by a commission of international scientists (preferably a ministerial commission).

Therefore, guidelines and protocols will have to comply with the scientific findings matured in the contexts of the most accredited European and world tsunami alert centres. Particular merit must be attached to the scientific documentation drawn up by the ICG/NEAMTWS and the IOC-UNESCO as international authorities responsible for centralizing and coordinating knowledge worldwide.

It is, therefore, necessary to create a detailed and continuously updated discipline, submitted to a process of scientific validation at both national and international level, especially for the fact that, in our case, the choices are made by the Centre that is then called upon to apply them.

There is no doubt that CAT has been accredited by NEAMTWS as a Tsunami Service Provider for the Mediterranean. The circumstance reminds us that the technical and scientific choices made so far by the CAT in terms of tsunamigenic risk management have already been the subject of an international validation process that has recognized its goodness and full applicability.

However, with the entrance in full operation of the CAT from 2017, it is necessary to prepare a series of documents that appear to be essential for the correct performance of the service: 1. job description document, containing the application procedures that guide the operators during the surveillance, and in the procedures for sending the first message to the DPC, in those for updating and closing the alert, as well as in the management of malfunctions that may be necessary during the performance of the service; 2. job description document of procedures reserved to the officer on call, as the person responsible for decisions taken during the development of the tsunami alert phases; 3. CAT general protocol which, also on the basis of the documents drawn up by the most accredited tsunami alert centres worldwide, defines the operational procedures of the service in all its forms, from the management and continuous verification of technical tools to staff training, from the procedural and scientific choices underlying the management of the alert to the instruments suitable to deal with malfunctions; 4. CAT-ISPRA protocol through which the synergy between the two institutes is regulated (with particular reference to the real time sea level data exchange of the ISPRA national network to CAT-INGV); 5. CAT-DPC protocol, through which the profile of communication of the existence of a potentially tsunamigenic earthquake and messages related to the development and closure of the alert is regulated in

the first instance. This procedure is broadly defined in the PCM Directive (2017), but it has to be integrated as soon as the system for alert message transfer from CAT-INGV to DPC and then to the whole civil protection system will be operational; 6. CAT-DPC-ISPRA protocol through which the three entities define the procedures for technical-scientific interaction and communication in the event of an alert or malfunction. The SiAM protocol is also an essential tool through which the development strategies of the service and the principles that should guide research are jointly defined; 7. guidelines to describe, also at international level: the scientific and procedural choices best suited to deal with tsunamigenic risk; the limits of the scientific knowledge currently available; the international debate developed around choices not yet fully shared; the research objectives.

Documents drawn up by the CAT CD, which will be constantly updated, must be translated into English and then submitted for approval by a scientific committee at national level and validation by the ICG-NEAMTWS. The result of this validation must then be translated again into English and submitted for the approval of ICG-NEAMTWS/ IOC-NEAMTWS.

Therefore, although guidelines and protocols are not considered by the jurisprudence as consubstantial cautions to the culpable reproach, suitable to become unequivocal precautionary rules, their centrality seems anyway unambiguous in the definition of the necessary cautions to face tsunamigenic risk.

6. Facing social uncertainty: assessing risk communication practices

Together with the analysis of the legal system and of responsibilities, a tsunami alert centre must follow well established procedures also as far as science communication and risk communication are concerned, considering that "when a hazard is unfamiliar and the threat is imminent, adequate mental models and clearly articulated messages become vital to one's ability to make decisions about life safety" (Sutton and Woods, 2016). The effectiveness of alert dissemination is strictly depending on the quality of risk communication issued before the event and on people's ability to recall information from the right sources. Hence, a well-grounded communication strategy is necessary both for gaining authoritativeness and credibility to be spent in case of an alert, and to release correct, updated, continuous, well-tailored information to the public, in order to increase risk awareness and to foster proper and adaptive social responses.

Any effective and sustainable risk communication strategy should be grounded on well-researched principles rather than good intuitions (Bostrom and Löfstedt, 2003), since good intuitions are indeed very likely to turn into undue assumptions and then in risk communication failures, or worse, in communication disasters. As demonstrated by L'Aquila *Grandi Rischi* Trial (Cocco *et al.*, 2015) risk managers, scientists and civil protection officers should pay closer attention to the ways they fulfil their risk communication duties, since *naïveté*, mistakes, improvisation and undue assumption on public's understanding can result into severe consequences, hence raising relevant questions about responsibility, liability and culpable reproach.

Risk communication is both a relevant part of the tsunami risk governance process and a crucial resource to mitigate impact on exposed coastal population. Given the glaring ethical implications

behind this observation, it is at once necessary and indispensable to operate according to the best scientific knowledge available, and communication strategy and practices should be grounded on well-researched principles (Paté-Cornell and Cox, 2014).

Furthermore, honesty, fairness, and pertinence, as well as public's involvement are recognized as fundamental ethical issues in risk communication: holding that any message may be misunderstood, risk communicators should collect information to improve their knowledge of public and to better understand how they think, crafting this information into risk communication plans (Lundgren and McMakin, 2013).

Hence, the lack of this information may turn into poor risk assessment, communication and management. The difficulty to establish a solid link between risk management and communication practices may indeed negatively affect the ability to address problems and develop an effective communication strategy (Veland and Aven, 2013; Cerase, 2017).

Tsunami risk poses a serious challenge to risk communication, since tsunamis in the NEAM region are relatively infrequent and unfamiliar for exposed coastal populations, if compared with other geo-hazard events, like earthquakes and volcanic eruptions. Such a challenge urges scientists and professionals to bridge the gap between theory and practice and to avoid inadequate theoretical frameworks, untested messages and misassumptions about public's knowledge and skills (Fischhoff *et al.*,1993).

In particular, three intertwined critical factors should be carefully addressed in order to establish an effective risk communication strategy within the tsunami field: a) long return time; b) lack of historical-cultural memory of previous events; c) lack of adequate information and knowledge about dynamics and effects of the phenomenon.

According to tsunami catalogues (Maramai *et al.*, 2014) return times of tsunamis in specific areas of the Mediterranean may span from hundreds to thousands of years; as a result, at local level it is very unlikely to find direct witnesses of past events, neither cultural expressions to be shared within the community about what tsunami is and what it is capable of causing (Oki and Nakayachi, 2012; Pasotti, 2014). As previous research suggests, people's beliefs about tsunamis are deeply affected by media images of Indonesia and Japan tsunamis, respectively occurred in 2004 and 2011 (ASTARTE, 2014; Goeldner-Gianella *et al.*, 2017; Liotard *et al.*, 2017).

7. Getting to know the public: what they know, what they think they know

To overcome these difficulties, risk communication about tsunami should consider public knowledge and feelings of people living along the coastline, to better address their understanding and perception of the phenomena and their personal attitudes toward risk mitigation measures. In addition, social research on risk perception may help Civil Protection and policy makers to identify the most appropriate channels and tools for the dissemination of alert messages, also improving scientific communication strategies and activities to be implemented by the CAT-INGV, including the development of dedicated websites and social media channels. The research is also aimed at integrating and enriching tsunami-related literature in the social sciences field, as most of the available contributions regard only a few coastal areas, where tsunamis are a historical reality, well-known by local populations.

In general terms, gathering and properly using information about public should be intended as a first step to provide tsunami warning centres with risk communication protocols and guidelines, geared toward establishing general principles that should be held essential or fundamental to steer risk communication activities. More in detail, protocols and guidelines may reduce the social uncertainty related to communication; provide a well-defined set of criteria to be followed by officials, establish courses of action consistent with available empirical evidence and prevent arbitrary behaviours that may amplify risks, or even damage reputation and credibility of scientific and governmental institutions.

Ongoing activities at CAT-INGV include the study of tsunami risk perception in southern Italy, that will address the communication strategy of the Centre.

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Corresponding author: Alessandro Amato
Istituto Nazionale di Geofisica e Vulcanologia
Via di Vigna Murata 605, 00143 Roma, Italy
Phone: +39 06 51860414; e-mail: alessandro.amato@ingv.it