Michael Havbro-Faber, on December 13-14, 2012, attended as an invited expert on catastrophic risks and risk informed decision making, the High Level Risk Forum, which was conducted under the auspices of the OECD, with participation of representatives of the G20 countries. The main focus of the meeting was directed on establishing a common framework for the G20 countries on the management of high impact risks within and across nations states. Based on a recent Press Release by the ‘Joint Committee on Structural Safety (JCSS)’ related to the problematic handling of the L’Aquila earthquake case in Italy, Michael was also asked to prepare and present a paper on the ‘Need for a Protocol on Risk Communication and Accountability’. The presentation which included mentioning of the ‘Life Quality Index’ principle as a common rationale for supporting societal life safety and health management and risk communication, was very well received by the G20 representatives. Based on their written appraisals, which are due in the beginning of 2013, further actions to implement such a protocol will be identified and initiated. The papers presented at the OECD HLR forum are attached to this document.
A Common Rationale for Health and Life Safety Management

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Abstract
In this paper, we provide a rationale for decision-making to enhance life safety that takes into full account the limitations and constraints of available resources. Maximizing life safety for all is a desirable goal but we need to acknowledge that the “safe” and the “dangerous” are inextricably intertwined in all human activities. We propose the marginal life saving principle together with the Life Quality Index (LQI) as a basis for supporting transparent decision making across all sectors at national and global scales; spanning over risk management related to natural hazards, industrial accidents, traffic safety, over nuclear incidents to development aid and disease control. The approach outlined here is practical and meets the requirements of fundamental human values as it relates to enhanced safety of individuals and it allows an explicit balancing of risk reduction with life saving benefits.

1. Introduction
Health and life safety are not only preferences of individuals but are globally considered to be important demographic indicators of the state of societal development. Individual societies and their developments are often analyzed and assessed in terms of cohort life tables, the life expectancy at birth, as well as indices like the Human Development Index (HDI) which at national scales combines the status of health with economic capacity and education.

Decision making with regard to allocation of available societal resources into activities aiming to improve health and life safety is an issue of national and global strategic importance. Management of risks, whether due to natural hazards or man made activities, industrial hazards Moreover, with limited resources and the pressure of the need for sustainable development, it is evident that this decision problem is not a trivial one; we all would like to have better health and life safety. However, the question is: How much life safety can we afford from a societal perspective? And a related question, equally compelling in times of restraint is: What is the societal capacity to commit resources to achieving the goal of maximum life safety?

The answer to this question is not only of fundamental importance for establishing a rationale for sustainable resource allocation purposes; it is of equal importance as basis for the necessary communication between public administration, industry and other private stakeholders on how and why priorities are set in sharing common resources for the purpose of risk management. In this position paper we provide answer to facilitate a rational basis for communicating decisions that critically impact health and life safety risk management.

Following Faber and Maes (2011) and Faber and Virguez Rodriguez (2011), we argue that that the marginal life saving cost principle together with the Life Quality Index (LQI) provides a sufficiently robust basis for decision making in regard to health and life safety investments not only at national scale but also at global or supra-national scale. Moreover, this framework, in sharp contrast to much present practice, accounts for the societal-economic capacity to commit
resources and societal preferences for investments into health and life safety improvements and thus greatly enhances sustainable societal development.

We start by addressing the general requirements that should be satisfied to support a rationale for investment into health and life saving activities on national or supra-nation scales. Thereafter the philosophy underlying the marginal life saving cost principle and the LQI is outlined. This framework for decision making about how society should invest shared resources into health and life saving activities conforms well with present practices of health and life risk management with small but important adjustments. Subsequently, the LQI is assessed at global scale and the potential benefits associated with the use of the LQI at national and supra-national scales are discussed.

2. Basic requirements for a common rationale on Life Safety Risk Management

Fundamentally we need to acknowledge a “zero risk society” does not exist. Risks to life safety are an integral part of our existence and any purposeful activity that we undertake to secure benefit, has some associated level of risk that varies dramatically from one economic sector to another. This leads to problems of prioritization when society must make difficult decisions about how limited available resources shall be allocated for life-saving purposes for the benefit of society. In this process it is important to ensure transparency of the decision-making process and a clear understanding that respect for societal ethical values remains paramount and no boundary conditions are imposed that could lead to knowingly “sacrifice” life safety and well being of individuals to the “greater good of the group.”. Effectively this implies that life-safety risk regulation must fulfill the following criteria (Elvik, 2008). Regulations must:

1. respect and build upon fundamental values related to human rights and safety for individuals;
2. conform to socio-economic mechanisms, resources and preferences;
3. be coherent with and manageable in relation to existing socio-political management processes; and
4. be implementable and unambiguous in practical applications.

Life-safety risk management at a societal level has been implemented in many countries for many centuries; The Netherlands provides one such example, see e.g., Ale (2002). Over the years the approaches utilized for safety management have become increasingly refined, and especially during the last 2-3 decades rigorous quantification of risk has entered into life safety risk management. Throughout literature and in a multitude of national and international codes and regulations (Jonkman, 2007), risk acceptance criteria for persons are defined and implemented for collective risks and individual risks independently, see Ale (2008), Hartford (2008) and Trbojevic (2008). The interpretations of individual and collective risks depend on the considered scale in space and time. If individual risk is understood as the risk to which one particular person is exposed, the integration or summation over the individual risks for all persons in society would result in the total collective risk.
Risk regulation must be in close relation to governing law (Ale, 2005) and, despite great similarities over different countries, different law systems may play a significant role in regard to the effective impact of best-practice risk regulation. A key difference is that in the common law system everything not specifically permitted is actually forbidden and vice versa, while in the Napoleonic law system everything not specifically forbidden is actually permitted. With this difference in view, however, the methodologies for risk assessment and the criteria for risk acceptance as implemented in the Netherlands and the UK do not differ significantly in practice, nor does the experienced level of risk.

The most widely applied concept in risk regulation is the so-called *As Low As Reasonably Possible/Practicable or Achievable (ALARP or ALARA) principle*. The idea is that risks, depending on their level can be classified as negligible, tolerable or non-acceptable. Risks that are negligible of magnitude in principle need no specific attention. All other risks are subject to an assessment with regards to how efficiently they may be reduced. According to the ALARP principle these risks shall be reduced until the costs associated with further reductions become disproportionate to the risk reductions.

In some cases risk regulations specify risk criteria which depend on the magnitude of the consequences. This phenomenon is referred to as *risk averseness* or *disaster averseness*. A risk-averse attitude in risk regulation implies that the loss of 1000 lives in individual accidents is less important that the loss of 1000 similar lives in one single accident. Risk aversion is clearly problematic as it does not provide equity in the societal regulation of risk, see also Maes & Faber (2007) and Schubert et al. (2007). Table 1 gives an overview of some criteria for individual risks.

Table 1. Overview of fatality rate risk criteria from the EU (Trbojevic, 2008).

<table>
<thead>
<tr>
<th>Annual fatality rate</th>
<th>UK</th>
<th>Netherlands</th>
<th>Hungary</th>
<th>Czech Republic</th>
</tr>
</thead>
<tbody>
<tr>
<td>$10^{-4}$</td>
<td>Intolerable limit for members of the public</td>
<td>Intolerable limit for existing industrial installations (ALARP)</td>
<td>Intolerable limit</td>
<td>Intolerable limit for existing industrial installations. Risk reduction must be carried out.</td>
</tr>
<tr>
<td>$10^{-5}$</td>
<td>ALARP region</td>
<td>Intolerable limit</td>
<td>Intolerable limit</td>
<td></td>
</tr>
<tr>
<td>$3 \times 10^{-6}$</td>
<td>Land Use Planning (LUP) criteria</td>
<td>Negligible</td>
<td>Intolerable limit for new industrial installations</td>
<td></td>
</tr>
<tr>
<td>$10^{-6}$</td>
<td>Broadly acceptable</td>
<td>Intolerable limit for new industrial installations and general limit after 2010 (ALARP)</td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10^{-7}$</td>
<td>Negligible</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>$10^{-8}$</td>
<td>Negligible</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

Table 1 shows that there is a very large variability associated with the implementation of the ALARP principle across different nation states. Moreover, in practice the ALARP assessment
of possible risk-reducing activities severely lacks standardization, leading to different approaches on how to assess the costs of risk reduction and inhomogeneous risk management.

Concerning risks associated with human activities of potentially extreme consequences the so-called precautionary principle deserves mentioning (COMEST, 2005). This principle has been formulated in the context of European risk regulation and is now applied in a large part of the World. The precautionary principle finds application in the assessment of activities for which there is no experience and for which there is suspicion that they might lead to extreme consequences. For such situations it is then required that more knowledge must be collected to ensure and document that such activities can be controlled and managed to a sufficiently high standard using known best-practice technologies. In many cases the precautionary principle results in the development of new technologies and in a way pushes the frontiers of best practice. Yet, the precautionary principle also hampers societal developments to some degree while ensuring that new and potentially dangerous activities can be controlled until they are sufficiently understood.

3. A rationale for life safety management

Societal health and life safety management across all societal sectors and activities, ranging from disaster risk management over development aid, traffic safety management and safety of structures to public health, may be addressed from operational and strategic perspectives:

- **Operational health and life safety risk management (i.e. for one project or activity) includes:**
  - Allocation of resources to a given project.
  - Implementation of these measures using available best practices.

- **Strategic health and life safety risk management includes:**
  - Prioritization of available economical resources between projects and activities.
  - Monitoring and improving present best practices.

Hitherto, societal decision making with regards to health and life safety investments has been approached mostly from a national perspective. Individual nation states make decisions on how to allocate their resources for the benefit of their citizens. However, there are issues of health and life safety which clearly go beyond the borders of individual nation states. This concerns e.g. sustainable global development, management of disease and global catastrophic risks, including mitigation of losses due to climate change. Decisions on such issues ultimately should be made on behalf of the global Earth society; a problem of allocation and prioritization of globally available and shared resources. The question in this problem setting remains: How to decide on how much we as a global society can afford and should invest into health and life safety improvements? The basis for supporting such decisions, whether in an operational or strategic context, and whether at national or at supra-national scale, should always be the same.

The prevailing principle (from health economics, see e.g. Linnerooth (1975)) for supporting decisions on health and life safety management is the *marginal life saving costs principle*. The basic idea behind this principle is that investments into activities that affect health and life
safety must be pursued until the costs associated with saving one more life exceeds a certain amount – namely the marginal life savings cost limit. The assessment of this amount has been subject to some scientific debate and various proposals, with significant variability in the amounts and philosophical basis that have been suggested in the literature.

A societal capacity and preference conforming basis for the assessment of the marginal life saving costs was proposed by Nathwani et al. (1997) in terms of the Life Quality Index (LQI). The philosophy behind the LQI is that the preference of a society in regard to investments into health and life safety improvements can be described at the level of societies characterized by a few of their demographical indicators i.e. the life expectancy at birth, the Gross Domestic Product (GDP) per capita and the ratio between working time and leisure time. In this way the LQI bears significant similarities with the Human Development Index (HDI). Whereas the LQI was originally proposed on the basis of socio-economic theoretical considerations, its validity has been empirically justified subsequently (Rackwitz, 2005; Kübler, 2005). The LQI facilitates the assessment of decisions with regard to their conformity with societal socio-economic capacity and preferences in regard to life safety investments. Based on the LQI it is possible to derive the amount of the marginal life saving costs, i.e. the necessary and affordable expenditures which should be invested into saving one additional life considering a specific activity for a given society, at the scale of nation states or supra-national scales. The LQI principle may be applied directly for decision support, not only for what concerns activities on life risk reduction but also for decision support concerning activities on health improvements by utilization of the demographical indicator Expected Life at Good Health instead of life expectancy at birth, see also Lentz (2004).

In Table 2 the marginal life-saving costs are provided for selected nation states as well as for the global Earth society corresponding to different schemes of risk reduction and assumptions concerning discount rates. Details on the quantification of the numbers provided in Table 2 may be found in Faber & Virgüez Rodriguez (2011).

Table 2  Marginal life saving costs considering risk reducing activities affecting the population proportionally (Π) and uniformly (Δ), respectively, for the year 2008 expressed in current thousand US Dollars for various discount rates.

<table>
<thead>
<tr>
<th>Region</th>
<th>G_Π (Age averaged and Discounted)</th>
<th>G_Δ (Age averaged and Discounted)</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>1% 2% 3% 4%</td>
<td>1% 2% 3% 4%</td>
</tr>
<tr>
<td>Canada</td>
<td>3,853.93 3,235.31 2,744.06 2,357.42</td>
<td>5,254.35 4,658.90 4,128.83 3,668.82</td>
</tr>
<tr>
<td>United States</td>
<td>3,466.90 2,932.00 2,503.33 2,162.57</td>
<td>4,226.44 3,756.29 3,338.17 2,974.93</td>
</tr>
<tr>
<td>China</td>
<td>176.04 149.10 127.41 110.09</td>
<td>234.22 209.27 186.86 167.19</td>
</tr>
<tr>
<td>Brazil</td>
<td>569.86 472.62 395.60 335.18</td>
<td>781.86 692.73 613.83 545.51</td>
</tr>
<tr>
<td>Australia</td>
<td>4,874.97 4,069.72 3,433.39 2,935.43</td>
<td>7,269.78 6,436.24 5,693.76 5,049.79</td>
</tr>
<tr>
<td>Mozambique</td>
<td>22.00 18.72 16.04 13.87</td>
<td>25.68 22.89 20.45 18.34</td>
</tr>
<tr>
<td>Mali</td>
<td>30.80 26.44 22.87 19.97</td>
<td>39.89 35.70 31.98 28.73</td>
</tr>
<tr>
<td>Dem. Republic of Congo</td>
<td>7.80 6.62 5.67 4.89</td>
<td>11.08 9.87 8.81 7.89</td>
</tr>
<tr>
<td>Earth (World Life Table)</td>
<td>501.13 422.10 358.74 308.38</td>
<td>653.81 581.60 517.46 461.69</td>
</tr>
</tbody>
</table>
Table 2 shows that the demographics of the societies play an important role in the marginal life saving costs. This facilitates differentiation of health and life safety management at societal level in dependency of societal socio-economic capacity and preferences.

The marginal life saving cost principle in conjunction with the LQI has found its way into a wide range of practical contexts in both public and industrial health and life safety management (Lind, 2012). Presently this framework is presently being implemented in the revision of the ISO 2394 “General Principles on Reliability of Structures” and will thus form the fundamental rationale on how and how much societies shall invest into structures for what concerns risk reduction with respect to e.g., natural disasters, safety with respect to terrorist attacks, industrial disasters, nuclear safety, safety in offshore and marine activities, and effects of climate change, in the future.

4. Use and implications of the proposed rationale

The marginal life saving cost principle is completely coherent with the philosophy of the ALARP principle. Therefore the ALARP principle may be suggested as the general principle for societal health and life safety risk management, providing that it be implemented in full consistency with the marginal life saving principle and the LQI.

In such an implementation the ALARP Principle may be formulated as:

1. Decisions and activities associated with life safety risks must be assessed in regard to the subsequently stated principles unless it can be documented that the risks are regulated by other prescriptive standards and regulations or the risks can be documented to be negligible.
2. Risk analyses must be performed in compliance with best practices such as outlined in JCSS (2008) and relevant ISO codes (e.g., ISO2394 and ISO 13824:2009).
3. Activities shall be assessed in regard to their societal acceptance in compliance with the marginal life saving cost principle. It must be demonstrated that life safety risks are reduced by means of best practice technical, organizational and procedural measures to a level at which further life safety risk reductions would exceed the marginal life saving costs as e.g. given in Table 2 (guidelines on how to undertake this demonstration may be found in e.g. Fischer et al. (2011)). Measures for risk reduction shall be sought from best practice, such as expressed in codes and standards, unless it can be justified that such are inappropriate in a given situation.

Although the marginal life saving cost principle does not necessitate or even allow for limiting the absolute values of the life safety risks, its practical implementation may require such boundaries. First of all to ensure that a full quantitative risk assessment is not required for situations for which risks are known to be small and where life safety risks are adequately managed by specific, often prescriptive regulations, codes and standards. Second, to ensure that, if absolute risks are indeed high compared to risks in general, the assessment in itself is performed in accordance to the state of the art and that the activity does not fall into the category of activities which should be assessed under the precautionary principle.
It is seen that this development of the ALARP format for the regulation of health and life safety risks satisfies all of the requirements formulated in the beginning of Section 2.

5. Conclusion
A clearly defined rationale on how and how much society shall and can invest into activities aiming to reduce risks to health and life is a prerequisite for sustainable developments but also a necessity as a basis for societal risk communication. Decisions on societal investments into health and safety must take basis in socio-economic capacity and preference of society to invest shared resources into risk reduction. Moreover, it must be ethical and facilitate societal democratic decision processes.

The marginal life saving cost principle in conjunction with the Life Quality Index provides such a rationale which, in addition, is coherent with the fundamental philosophy of the ALARP principle that presently may be considered a best practice on national risk regulation. It is suggested that the marginal life saving cost principle together with the LQI be implemented at broad scale as basis for national and supra-national risk management and risk regulation. Using this framework all societal activities and decision making on health and life safety investments may be assessed and communicated on a common and consistent basis and thereby greatly enhance sustainable development. At the same time this facilitates an informed transparent communication between all societal stakeholders on issues of health and life safety risk management.

References


Lind N. & Nathwani J. (2012) LQI Bibliography and Abstracts. LQI Symposium, DTU, Denmark, August.


THE NEED FOR A PROTOCOL ON RISK COMMUNICATION AND ACCOUNTABILITY

Michael Havbro Faber, DTU and Niels Lind, University of Waterloo

Abstract

Decisions about communication of risks to the public are many and vary greatly in quality for lack of good data and rational evaluation. To provide a clear basis for an open and justifiable decision process this paper proposes a standard protocol format of communication and a valuation based on the economics of human welfare.

Introduction

Government decision makers and the citizenry are often confused when they receive statements about risks confronting the general public; such statements are often vague, incomplete and doubtful. Moreover, these stakeholders may have little knowledge about how to make the best decisions under major uncertainty. As a result, public authorities and the citizenry remain uncertain about how to act. There is a need for clarity: a reliable basis of data, and a rational process going from data to the decision. A standard protocol on risk communication would go a long way to make it clear what action, if any, should be taken. Such a standard, together with a justifiable valuation of potential losses, would also help public officials meet higher standards of accountability as is to be expected in a developed society.

These two needs, standard protocols of communication and evaluation of risks, are illustrated by events around the disastrous Mw-6.3 earthquake in L’Aquila, Italy on 6 April 2009 that killed some 300 persons. The Italian Civil Protection agency was broadly and severely criticized for ignoring the foreshock activity. But, following a particularly large foreshock, a meeting of scientists and civil protection officials was convened on the evening of 31 March 2009. The meeting recommended no further mitigation and no evacuation. This recommendation was heavily criticized in hindsight by the mass media and the public (van Stiphout et al., 2010). Six persons attending that meeting were accused of giving "inexact, incomplete and contradictory" advice and convicted of manslaughter in a local court this year. There is broad concern about the possible causes and consequences of this verdict.

Scientists, governments and engineers must continue to serve the public interest – also on issues that are associated with significant uncertainty. This is a necessity for sustainable societal development. As the case stands, it is very doubtful that experts and professionals in risk and hazard management will dare to provide decision support for societal decision makers in the future. There is an urgent need to establish and strengthen best practices on risk management in the public domain.

At present there is an inappropriate diversity of legal, organizational, strategic and operational approaches to risk management, between and within nation states and industries. This problem should be addressed by a broad international authority to establish a common dispassionate rationale for societal risk management.

Divergent information among experts, societal decision makers and the public about risk is a serious problem in societal risk management, causing misunderstanding and unrealistic expectations among the
parties. We need to define and disseminate best practices of risk management in: methodology, quality, organization, distribution of responsibilities and liabilities, and communication.

The responsibility for disseminating appropriate information and taking suitable precautions rests with government. Societal decision makers are accountable and should therefore seek advice from subject-matter experts; e.g., scientists and specialized engineers. Scientific risk assessment is the strongest available rationale to support decision making in the face of possible catastrophes. Societal decision makers should, in the interest of the public, have an adequate informed and trained understanding of risks and best practices in risk management in order to be able to validate, confirm and assess the quality of professional advice they receive.

Subject-matter experts shall provide their advice in accordance with the state of the art and the best practices within their area of expertise. Impartiality, objectiveness and ethical conduct in general, are to be exercised and expected to meet the highest standards. Still, in many cases the available knowledge about hazards is limited to estimates on the probability of different possible scenarios. Due to the underlying and unavoidable uncertainties, the quality of scientific advice concerning risk management cannot be judged on the success of predicting events or avoiding losses, but only on the quality of the underlying probabilistic/statistical analyses and risk assessments.

Risk management must be ethical on first principles (and also affordable by the society). Disaster risk management is to a large extent the responsibility of societal decision makers; politicians and government representatives. Governments are obliged to have adequate disaster preparedness programs and inform the citizenry about risks so that citizens can take well-informed precautions. Confusion and misunderstandings can be prevented only if information about risk is presented in a dispassionate and precise format. To this end we propose a quantified format of risk communication – “Numbers, not adjectives” (MacKay, 2009) – in a standard format of protocol. In Section 5 we present a summary of valuation by the Life Quality Index that is based on welfare economics.

A Standard Protocol for Scientific Risk Communication

In developed societies life is safer than ever in history, as witnessed by the life expectancy at birth which has grown enormously during the last century and is still growing almost everywhere on Earth. Nevertheless, the number of hazards present in technologically advanced countries is huge, as is the number of possible risk-reduction interventions (Tengs et al., 1995). Officials and the public need to be informed in a balanced way about the plethora of risks so that they can appreciate societal efforts on managing risks, understand prioritizations and to facilitate that they can make rational decisions in specific situations. We present here a proposed unified format to support communication for three distinct situations, namely before a hazard event, during a hazard event and after a hazard event.

Risk communication before, during and after disaster events

Communication of risks to the public is an important part of risk management. Consequences associated with the public perception of disaster events depend strongly on the information disseminated before the event. Moreover, unbiased communication about risks supports the development of a risk culture and enhances rational behavior. Information symmetry among stakeholders is a well-appreciated prerequisite for collaborative efforts as needed in public disaster risk management.

Communication about risks should encompass the entire context of risk management, at different societal levels, addressing different groups of stakeholders and cover the situations before, during and after disaster events. The general public should be informed about:
• Why is risk management essential in public governance?
• What are the risks to which the public are exposed – where do they come from and what has happened before?
• Who is responsible for public risk management – before, during and after events?
• Which responsibilities and liabilities lie in the hands of government officials?
• Which responsibilities concerning risk management do the public carry, and how can individuals and industries actively contribute to risk management?
• How are decisions made concerning risk management in society – what is the basis for deciding on what and how much to invest?
• What is being done to reduce risks before and during disasters?
• What are the precursors of different disasters?
• What is to be expected if disaster strikes - what are the likely and possible scenarios and the corresponding consequences for people, environment and societal functionalities?
• What to do if disaster strikes?
• What help can be expected in the case of a disaster, during and after the event?

The during-disaster situation covers the time from the first observation of possible disaster precursors over the strike itself, until the time when rescue, evacuation and/or other tactical loss-reduction activities can be ceased. Of course, for some disasters there are no precursors. During this period of time, based on the actual knowledge of the emerging or evolving event, the public should be informed about:

• What are the observations of precursors of the disaster and their interpretation in terms of likely reasons and possible further scenarios?
• What is the estimated intensity and duration of the anticipated event?
• What are the likely consequences and their extent in time and space?
• Which societal functions are likely to be lost and for how long?
• How best to protect themselves, other persons, the environment and assets?
• If, how and where to evacuate?
• Where and how to get help?
• What to do when the disaster event is over?
After disaster events – what happened and why could it happen? The public should be informed about:

- The extent of the consequences
- Why the disaster could happen and the losses take place?
- What can be learned from the disaster?
- Will the disaster lead to a change in priorities in disaster risk management? And, if not, why?

A scientific message about a risk to the public shall be dated, quantitative and (1) state precisely the intended recipient(s), describe (2) the hazard, (3) the set of possible consequences considered over (4) a specified extent in space and time. The (5) author shall be stated, with contact information.

**Detail and format for risk communication**

Communications about risks should clearly specify to which recipient(s) it is intended, from where it originates and who has produced it. For the hazards, probabilities, consequences and their extent over time and space the communication shall be quantitative and its basis shall be specified.

**Intended recipient(s)**

The *recipient* is a decision maker, usually a government or other authority. It can also be a company or companies, addressed to the executive. If the message is for households or individuals through the media, the message shall be phrased dispassionately in appropriate clear language devoid of jargon.

**Hazard**

The *hazard* and possible interactions between hazards shall be identified and described in sufficient detail.

**Consequences**

The *consequences* is a clearly specified and preferably complete set of the possible scenarios leading to losses caused by the hazard. If there are some scenarios and possible losses that are not considered they shall also be stated.

**Extent**

The *extent* is a geographic area, jurisdiction or set of persons exposed, together with the period of time considered.

**Probability Estimates**

The *probability estimates* shall be numerical, one assigned to each element of the set of consequences.

**Uncertainty Measure**

The uncertainty in the probability estimates shall be stated quantitatively.
**Author**

The author, whether a person or institution, shall be stated together with contact information so that the risk statement can be clarified or assessed for its reliability.

**Basis**

The *basis* for the risk estimate, normally a report, shall be referenced together with a statement about peer review.

**Example 1 -- Earthquake**

Following a June 14, 2010 M 5.7 earthquake the California Earthquake Prediction Evaluation Council (CEPEC) issued the following statement.

"The earthquake was the largest aftershock so far of the Mw 7.2 El Mayor-Cucapah earthquake that occurred on Easter Sunday. This earthquake occurred at the northern end of the aftershock zone in an area where there has been considerable activity during the past 10 weeks. The Mw 5.7 earthquake rapidly was followed by a tight cluster of over 30 smaller earthquakes, about 20 of which were in the range of Mw 3.0 to 4.5.

"CEPEC convened a teleconference call at 22:30 hrs PDT to discuss the implications of the aftershock. It occurred along the southernmost portion of the Elsinore Fault Zone, which has not had a major earthquake in the past 100 years or so. Because of the location of the Mw 5.7 aftershock, CEPEC believes that the probability of a larger event on the Elsinore Fault or the San Jacinto Fault has increased considerably, and will remain so for several days, although the absolute probability remains low, on the order of one percent. CEPEC will continue to monitor the situation." (CEPEC, 2010)

Although this statement is quite complete, the recipient might benefit from one that follows the proposed standard protocol, as for example:

*This information is for The Governor of California via the California Office of Emergency Services concerning the Hazard of an earthquake of magnitude larger than Mw 5.7 on the Elsinore Fault or the San Jacinto Fault. The expected Consequences of such an earthquake are [e.g., a loss of 100-500 lives and property damage of $B 2-50], extending over [e.g., the zone within 40 km of the two faults, over the period June 15-22.] The probability of such an event is estimated at [e.g., one percent.] The uncertainty in this estimate is large: [e.g., ±70%]. This estimate has been provided by: [e.g., the California Earthquake Prediction Evaluation Council (CEPEC). For further information contact Dr John Smith, Tel. . . etc.]; This risk estimate [e.g., was made after deliberations in a June 14 teleconference call at 22:30 hrs PDT. There has been no peer review. On behalf of CEPEC John Smith, Chairman.]*

**Example 2 – Seasonal Influenza**

Seasonal Flu annually presents a considerable threat to the population worldwide. In the USA, for example, it “causes more than 200,000 hospitalizations and 41,000 deaths in the U.S. every year, and is the seventh leading cause of death” in the USA (Beigel, 2008), having varied from 3,300 to 49,000 deaths per year over the past 30 years (CDC, 2010; Steenhuylsen, 2010). Molinari et al. (2007) estimate that in the USA “annual influenza epidemics result in approximately 600,000 life-years lost, 3 million hospitalized days, and 30 million outpatient visits, resulting in direct medical costs of $10 billion annually . . . and the average of all direct and indirect economic burdens of annual influenza epidemics . . . amounts to over $80 billion.” There is a vast literature on the subject, detailing the effectiveness of vaccination as it varies with age group and exposures (e.g., school children or health-care workers).
Decisions about flu vaccination must be made by many agencies and by the individual. Every year citizens need the information required to make a rational decision about whether or not to be vaccinated. It is generally thought that vaccination is very effective, but many people hesitate to be vaccinated.

For the sake of illustration we restrict this example to people in the USA older than 65 years. “Every year individuals need the information required to make a rational decision about whether to be vaccinated. Influenza vaccines . . . cut the risk that elderly people will die of the virus in half and reduced the chance of hospitalization by more than a quarter, according to a study . . . by the New England Journal of Medicine . . . In a non-pandemic year, a person in the United States aged 50–64 is nearly ten times more likely to die an influenza-associated death than a younger person, and a person over age 65 is over ten times more likely to die an influenza-associated death than the 50–64 age group” (Thompson et al., 2003). Thus, 85% of these deaths are in the 65+ age group; using US census data for year 2000, if the annual deaths from the Flu is 41,000 in a population of 281.4M, then there are 35,000 in the 65+ age group totalling 35M, so their annual probability of death resulting from Flu equals 0.001. If the efficacy of the vaccine is 50%, and if half the population is vaccinated, then the benefit of vaccination for people 65+ equals a gain in life expectancy of roughly 3 days. The protocol, when supplemented with information about the effectiveness of vaccination, can support a rational individual decision along the following lines:

This Information is addressed to residents of the USA over 65 years of age and their advisors, concerning the annual hazard of seasonal influenza. The well-known expected consequences for your age group of some 40M persons are more than 200,000 hospitalizations and 40,000 fatalities every year. The probability of contracting the Flu is about [e.g., 1 in 10]; of hospitalization [e.g., 1 in 50]; and of death from the Flu or complications is [e.g., 1 in 1000]. The uncertainty in these estimates is large, perhaps ± 70%. These estimates have been provided by: [e.g., Dr John Smith of the CDC. For further information contact your physician]. This risk estimate [e.g., was made on the basis of national statistics available to the Center for Disease Control.] There has been no peer review.

Vaccination cuts your risk of death in half and reduces the chance of hospitalization by more than a quarter.

Risk-based Decision Making

Members of the public have considerable freedom to evaluate a risk as they deem fit. But public officials are accountable and must decide rationally, ethically and dispassionately on behalf of the public. In doing so, they must place a relative valuation of losses of life, health and injury against losses of material, environmental and sometimes cultural value. The onus is on the responsible official to consult with qualified professionals and to communicate openly the decision basis, citing the decision basis, e.g., the cost-benefit differential or the JT-value (Thomas & Jones 2010). For further information see: Faber et al. “A Common Rationale for Health and Life Safety Management,” OECD High Level Risk Forum, Dec. 13-14, 2012.

For example, van Stiphout et al. (2010) have introduced an approach, the Short Term Earthquake Risk (STEER) analysis that combines time-dependent probabilistic seismic risk assessment with a conventional cost-benefit analysis. Their solution requires a valuation of evacuation time against a valuation of material loss and loss of life. For evacuation they considered various amounts, such as $500 per 24-hour per person; they used $1M per fatality, taken to be the “Willingness to Pay for Life Saved”, acknowledging that the amount of money available to reduce life risk is limited. This value was also used previously in a study of volcanic risk around Vesuvius (Marzocchi and Woo, 2009).

Willingness to pay for a life saved – or, rather, a fatality postponed – is a subjective quantity, of course, and is a very weak element in cost-benefit analysis. The different approach by Nathwani et al. (1997, 2009)
uses welfare economics theory to derive the average relative societal value of a unit of time allocated to work against time gained by extending life expectancy. They established the Life Quality Index (LQI), a canonical function of life expectancy at birth and Gross National Product per capita. From this function the Societal Capacity to Commit Resources (SCCR) is derived, specific to each polity and time of loss. If the LQI is based on quality-adjusted life expectancy, then the valuation also extends to injury and illness. Any decision about a public risk should openly be put in the perspective of the Societal Capacity to Commit Resources.

**Conclusion**

1. Decisions about risks to the public require reliable data and a rational decision process. A standard protocol on risk communication will clarify and justify the decisions, helping officials reach higher standards of accountability when supported by a valuation of potential losses.

2. The present variability in public risk management should be addressed by broad international authority to establish a general protocol for dispassionate societal risk management.

3. Societal decision makers require expert advice and the education to necessary to appraise its quality. We propose a standard risk communication format, quantified. “Numbers, not adjectives.”

4. A risk communication should specify its author and intended recipients. The hazard, consequences, probabilities and their extent should be quantified and documented.

5. Public officials should decide openly, rationally, ethically and dispassionately on behalf of the public. In risk assessment they must evaluate loss of life and health relative to material values. Official should consult with experts and openly communicate the valuation. The Life Quality Index (LQI), a function of life expectancy at birth and Gross National Product per capita, accurately defines the societal capacity to commit resources and provides an unequivocal measure of all public life risk management.
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