The Effectiveness of Risk Communication to Raise Awareness of Natural Hazards

Humair-Charriere, Marie

DOI
10.4233/uuid:2b8835de-5f43-4c41-b940-80e566f5554d

Publication date
2018

Document Version
Final published version

Citation (APA)
Humair-Charriere, M. (2018). *The Effectiveness of Risk Communication to Raise Awareness of Natural Hazards*. [Dissertation (TU Delft), Delft University of Technology]. https://doi.org/10.4233/uuid:2b8835de-5f43-4c41-b940-80e566f5554d

The Effectiveness of Risk Communication to Raise Awareness of Natural Hazards

Marie Humair-Charrière

The Effectiveness of Risk Communication to Raise Awareness of Natural Hazards

The Effectiveness of Risk Communication to Raise Awareness of Natural Hazards

Proefschrift

ter verkrijging van de graad van doctor
aan de Technische Universiteit Delft,
op gezag van de Rector Magnificus Prof.dr.ir. T.H.J.J van der Hagen
voorzitter van het College voor Promoties,
in het openbaar te verdedigen op
maandag 3 december 2018 om 12.30 uur

door

Marie Katerina Madeleine HUMAIR-CHARRIÈRE
Master of Science in Geowetenschappen
University of Lausanne, Lausanne, Switzerland
geboren te La Chaux-de-Fonds, Switzerland

This dissertation has been approved by the

promotor:	Prof.dr.ir. N.C. van de Giesen
promotor:	Dr. T. Bogaard
copromotor:	Dr. E. Mostert

Composition of the doctoral committee:

Rector Magnificus	chairman
Prof.dr.ir. N.C. van de Giesen	Delft University of Technology
Dr. T. Bogaard	Delft University of Technology
Dr. E. Mostert	Delft University of Technology

Independent members:

Prof.dr.mr.ir. N. Doorn	Delft University of Technology
Prof. dr. B. Malamud	King's College London, United Kingdom
Prof. dr. P. Osseweijer	Delft University of Technology
Dr. M. Buchecker	Swiss Federal Research Institute WSL, Switzerland

TU Delft

ISBN: 978-94-028-1295-4
printed by: Ipskamp printing
cover design: Alexis Charrière

An electronic version of this dissertation is available at
http://repository.tudelft.nl/

La vraie cause des échecs de l'éducation formelle tient ... essentiellement au fait que l'on débute par le langage ... au lieu de débuter par l'action réelle et matérielle.

Jean Piaget

to Jeanne and Marie-Juliette
to Edgar

Summary

Natural hazards occur every year throughout the world, with catastrophic consequences. There are several ways to deal with this problem, among which raising risk awareness of the populations at risk. Risk communication, and in particular visual risk communication, is a tool that can help to reach this objective if it is effectively designed. The evaluation of the effectiveness is crucial to any communication effort and its importance is recognized in both the scientific and the disaster risk reduction community. Nevertheless, very few evaluations of the impact of risk communication efforts are available.

This doctoral thesis studies the effectiveness of real-life risk communication efforts that include visuals and aim to increase the awareness of populations at risk of natural hazards. Several methods are used. To obtain a picture of the current state of research and practice, a qualitative approach is followed, including a literature review of risk communication concerning floods and interviews with designers of Smartphone Apps on avalanche danger. To measure the effectiveness of a real risk communication effort, a quantitative approach is followed, including statistical analysis of survey responses and Radio-Frequency Identification technology. The studied risk communication effort is the 'Alerte' exhibition, held in the French Alps, which was designed with the local stakeholders following an action-oriented approach.

The literature review and the interviews both point to the need for more evaluation of the effectiveness of risk communication. The evaluation of the 'Alerte' exhibition shows that it has increased the visitors' awareness of natural hazards and related risks. Moreover, the action-oriented approach used to design the exhibition proved to promote dialogue within the community. Finally, Radio-Frequency Identification technology proved to be a promising tool to time and track visitors at the exhibition and assess their preferences concerning the content and format of the different exhibits.

This doctoral thesis confirms the importance of evaluating the effectiveness of risk communication. It also participates to build the knowledge on how to operationalize the measurement of changes in the cognitive process of risk awareness. Finally, it provides guidelines for further risk communication campaigns in mountain areas.

Table of Contents

1. Introduction

This doctoral thesis evaluates the effectiveness of visual risk communication that aims at increasing awareness of the risks posed by natural hazards. It evaluates more specifically the effectiveness of an exhibition on mountain-related risks that was organized in the Ubaye value in France and in Romania.

1.1 NATURAL HAZARDS, RISK AND RISK COMMUNICATION

Natural hazards are physical phenomena such as earthquakes, volcanic eruptions, floods, storms or mass movements (Smith, 2013). Every year, natural hazards impact on human society and many disasters take place. The reinsurance company SwissRe (2017), for example, stated that in 2016, an average year in terms of human and economic losses, 191 natural catastrophes killed approximately 7000 people worldwide and economic losses reached USD 166 billion. These numbers are very likely underestimations, as SwissRe only takes into account larger disasters: more than USD 49.5 million insured losses, more than USD 99.0 million total economic losses, or more than 20 lost or missing lives, 50 injured or 2000 homeless (SwissRe, 2017). Moreover, SwissRe's insured losses linked to weather-related events have followed an upward trend since the 1970s (SwissRe, 2017). Others have noted an upward trend in losses too (e.g. Choffet, 2013). Reasons for this upward trend are numerous and include increases in the number of natural hazard events, the number of buildings, the real estate value as well as the vulnerability of assets and goods (Choffet, 2013).

Since two decades, the International community has recognized the need to tackle disasters linked to natural hazards, as these put the world's economy and population and the development of developing countries at peril (UNISDR, 2007). In 2000, the International Strategy for Disaster Reduction (ISDR) was adopted by the United Nations. This was followed by the creation of the Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disaster, which was recently succeeded by the Sendai Framework for Disaster Risk Reduction 2015–2030. Developed countries can also be severely impacted by natural hazards as shown by the effects of hurricanes Katrina in 2005, Sandy in 2012, Irma in 2017, and the tsunami that hit Japan in 2011.

Several natural hazards can occur at the same place and time and interact in many ways, e.g. an earthquake inducing a tsunami. The term multi-hazard can be used when this is the case (Gill & Malamud, 2014). In this doctoral thesis, possible interactions between natural hazards are not addressed. Thus, multi-hazard is used to describe a location that is affected by multiple natural hazards or to refer to risk communication efforts that give information on more than one natural hazard. The term risk is simply defined here in terms of consequences, as the potential losses of a society affected by natural hazards, rather than as a combination of consequences and probabilities or as a probabilistic function of the natural hazard, the vulnerability, the exposure and the capability (UNISDR & UNGA, 2016).

Risk communication can be described as the transfer or exchange of information, knowledge, attitudes and values about natural hazards, the related risks and their management (Höppner et al., 2010). Risk communication is essential for Disaster Risk Reduction (DRR): it can help to build a culture of safety and resilience through knowledge and education (3rd priority for action of the Hyogo Framework (UNISDR, 2007)) and increase understanding of disaster risk (1st priority for action of the Sendai Framework (UNISDR, 2015)). In this regard, risk communication can have many goals (Höppner et al., 2010) such as raising awareness, trigger action to impending events or reassuring the audience. Basically, the aim of risk communication is to decrease vulnerability of populations to natural hazards and therefore reduce their impacts on the human society.

Since almost three decades, societal trends have facilitated risk communication, such as (i) the growth of the information society and (ii) the increasing interest in health and security information (Fildermann, 1990). The first trend relates to the fact that people have access to many types of information and many media that are in competition between each other. The second trend refers to the current inclination of society to consider and balance costs, risks and benefits when decisions are made in the domains of health and security.

1.2 RAISING AWARENESS

An important goal of risk communication is often raising public awareness (Höppner et al., 2010). Public awareness is defined by UNISDR (2009) as “the extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards”. It is important to consider such a cost-effective non-structural mitigation measure (Kelman, 2014) as public awareness raising as a complement to less cost-effective structural mitigation measures, such as dikes or rockfall drapery mesh. Raising public awareness of the population at risk is important, but this is especially important when funding for structural risk mitigation is limited.

Risk awareness is not only about hard factual knowledge: attitudes to risk and the ability to mitigate (Enders, 2001) are also part of it. In addition, factors such as demographics, level of worry or previous experiences have an impact on it. Consequently, risk awareness is a complex multi-dimensional concept and its operationalization must be further investigated.

1.3 VISUAL RISK COMMUNICATION

In addition to being written, as in a report, or spoken, as at a public meeting, risk communication can be visual, using tools such as graphs, charts, pictures, drawings, movies, maps and even objects. In our society, we see much more visuals than we read text (Lester, 2013). Visual communication has several advantages, such as the capacity to convey strong messages, condense complex information and communicate instantaneously (Nicholson-Cole, 2005). For risk communication, the benefits of using visuals are to help the target audience understand, reflect and remember content, to make the information more rapid/realistic/accurate, to clarify abstract concepts, and to put facts into context (Schwarzenegger & Renteria, 2006).

Nevertheless, as with any communication mode, visual communication has limitations and drawbacks. Bresciani & Eppler (2008) classified the disadvantages of visualization according to their causes (designer or user induced) and their types of effects (cognitive, emotional or social). The messages may for example be ambiguous and difficult to understand, provoke visual stress or affect behavior in an unintended way. Therefore, when used for risk communication purposes, visuals can potentially be ineffective or even counter-productive.

1.4 RISK COMMUNICATION EFFECTIVENESS THROUGH EVALUATION

Figure 1.1: Six stages of communication. Simplified from Austin & Pinkleton (2015, p.72)

The development of any communication effort follows several stages (an example of six general stages is given in Figure 1.1). Similarly, it is crucial to evaluate the effectiveness of risk communication efforts in order to determine whether the communication efforts attain their goals (e.g. Covello et al., 1991 and Lundgren & McMakin 2004). This can help to improve future efforts (e.g. McCallum, 1995 and Lundgren & McMakin 2004), or to choose between alternatives practices (e.g. Rohrmann 1992).

With respect to risk communication efforts aiming at Disaster Risk Reduction, the importance of evaluating effectiveness lies in the fact that they can influence the way people manage the risks (Renn, 2005). The effectiveness of risk communication efforts can be evaluated using three criteria (Rohrmann, 1998):

i. the content (for example, is it correct and does it meet users' needs?),

ii. the process (for example, were all the relevant actors involved?),

iii. the outcomes (for example, did the communication effort improve comprehension or change the attitude of the targeted audience?).

Risk communication evaluation is not a straightforward process due to several issues, such as the values used to conduct the evaluation, the precision of the goals of the risk communication efforts, the resource needed to carry it out and its usefulness (Covello et al., 1991). Concerning outcomes evaluations, the main problems lie in observing the change or changes that the communication effort triggered and the research design that will allow to measure it or them meaningfully (Neresini & Pellegrini, 2008). These problems might explain how risk communication efforts concerning natural hazards are currently evaluated. They are usually assessed in terms of users' requirements, ability to understand the content, or satisfaction with the diverse components of the effort. They hardly focus on their real impacts and effects. Moreover, research is mostly conducted in lab-environments rather than on real communications efforts (Charrière et al., 2012).

1.5 RESEARCH OBJECTIVE, RESEARCH QUESTIONS AND APPROACH

The four main elements discussed above form the background of this thesis and are as follows:

i. The fact that raising awareness is an important non-structural mitigation measure that is often stated first in the list of risk communication goals.

ii. The importance of visuals for risk communication.

iii. The importance of evaluating risk communication practices and the issues related to the evaluation.

iv. The lack of scientific evaluation of the effects of real risk communication efforts concerning natural hazards.

Against this background, the objective of this thesis is to increase insight in the effectiveness of real risk communication efforts that use visuals and aim at increasing public risk awareness of natural hazards. To this end, this thesis will address the following research questions:

1) How are risks related to natural hazards currently communicated?
2) How are these communication efforts currently evaluated?
3) Can a real-life risk communication effort using visuals increase risk awareness of natural hazards?
4) How attractive are different visuals at an exhibition for different groups of visitors?

To answer these questions, this doctoral thesis follows an empirical rather than a theoretical approach. Nonetheless, several theoretical frameworks are used. First, this thesis follows the body of literature on risk communication that states that evaluating the effectiveness of any risk communication effort should be an integral part of its design. Secondly, it considers risk awareness of natural hazards, as a complex cognitive process and adopts the framework of Enders (2001) for measuring community awareness and preparedness for emergencies. And thirdly, the fieldwork for this thesis was conducted according to an action-oriented research approach inspired by Small & Uttal (2005). Hence, the research was carried out in collaboration with the local stakeholders, expecting that our research activity would be beneficial and significant for the local community as well as for science. The research methods used in this doctoral thesis include literature review, questionnaires, interviews and visitor's tracking using Radio-Frequency Identification. This will be explained in more detail in the various chapters.

1.6 THESIS OUTLINE

This thesis is organized as follows. Chapter 2 provides an overview of the current risk communication practices related to natural hazards and the way in which they are evaluated. The focus is on flood risk communication as most of the work that has been conducted, both in term of practice and research, is related to flooding.

Chapter 3 extends the topic of current risk communication practices. It describes how smartphone applications that aim at increasing risk awareness of avalanches are designed and evaluated. Snow avalanches are the only natural hazard for which there is an international standard for danger levels, and consequently only the way in which information on danger levels is presented – visual, text, hierarchy, etc. – differs. This chapter is mainly based on interviews with the developers of smartphone applications.

Chapter 4 describes how the adopted action-oriented approach determined the choice of the real communication effort that is evaluated in chapter 5, the 'Alerte' exhibition.

Chapter 5 analyses the 'Alerte' exhibition and its impact on the risk awareness of the population. The exhibition was held in the Ubaye valley in the southern French Alps. In this area, at least five natural hazards occur: floods, debris flows, landslides, earthquakes and snow avalanches. The central method used in this chapter is a statistical analysis of the results of a questionnaire-based survey, using a pre-test/post-test research design.

Chapter 6 evaluates in some detail the attractiveness of the visuals used in the 'Alerte' exhibition and a sequel exhibition in the Buzău County, Romania, as well as the satisfaction that they provided to the visitors. The main method used in this chapter is Radio-frequency Identification, a technology that allowed the tracking of the visitors in the exhibitions.

Chapter 7 summarizes the thesis and reflects on how to evaluate the effectiveness of risk communication related to natural hazards as well as on its impact on risk awareness. Some biases linked to this research are provided as well as personal reflections on doing research in-between social sciences and geosciences. Finally, the chapter concludes on perspectives for further research.

1.7 MARIE CURIE INITIAL TRAINING NETWORK "CHANGES"

This PhD thesis was conducted in the context of the Marie Curie Initial Training Network (ITN) project "Changes – Changing Hydro-meteorological Risks as Analyzed by a New Generation of European Scientists", which lasted from January 2011 to December 2014 and was funded by the European Community's 7th Framework Programme: FP7/2007-2013 under the Grant Agreement No. 263953. The overall goal of this ITN project was the analysis of the effects of climate, environmental and socio-economic changes on the temporal and spatial distribution of hydro-meteorological hazards and related risks in alpine areas. Along with the modeling and assessment of the impact of these changes on hazards, vulnerability and risk, the implications for future risk management strategies, such as spatial planning, emergency preparedness and risk communication, were studied as well.

The "Changes" Marie Curie ITN project included 11 academic partner institutions and 6 associated partners. It was coordinated by the International Institute for Geo-Information Science and Earth Observation of the University of Twente, The Netherlands. Mobility of the PhD researchers being a priority in Marie Curie ITN projects, secondments for this thesis were spent at the Institut de Physique du Globe, Université de Strasbourg (France) and at the Faculty of Spatial Planning, Technische Universität Dortmund (Germany).

Four European areas were pilots study sites in the "Changes" project: Ubaye valley (France), Friuli Venezia Giulia region (Italy), Buzău county (Romania) and Wieprzówka catchment (Poland). This thesis focused on the French pilots study site for two main reasons: 1) risk management, in which risk communication is embedded, is more advanced than in some of the other pilots study sites, and 2) the topic being risk communication, mastering the language of the case study area was perceived as a crucial element that would facilitate interaction with the local stakeholders.

1.8 REFERENCES

Austin, E. W., & Pinkleton, B. E. (2015). Strategic Public Relations Management: Planning and Managing Effective Communication Campaigns (Vol. 10). Routledge.

Bresciani, S. & Eppler, M.J. (2008). The risks of visualization – A classification of disadvantages associated with graphic representations of information. Working Paper. Institute for Corporate Communication, Faculty of Communication Sciences, Università della Svizzera Italiana.

Charrière, M.K.M., Junier, S.J., Mostert, E., and Bogaard, T.A (2012). Flood risk communication – Visualization tools and evaluations of effectiveness. Proceedings of the 2nd European Conference on FLOODrisk Management, November 20-22, 2012, Rotterdam, The Netherlands.

Choffet, M. (2013). Les coûts des dommages éléments naturels aux bâtiments et l'influence des facteurs du risque dans un contexte d'assurance immobilière - Analyse de cas des inondations et de la grêle en Suisse. Thèse de Doctorat. Faculté des Géosciences et de l'Environnement. Université de Lausanne

Covello, V., Fisher, A. & Bratic Arkin, E. (1991). Evaluation and effective risk communication: introduction. In A. Fisher, M. Pavlova & V. Covello (eds.), Evaluation and Effective Risk Communications Workshop Proceedings: xi-xvii. Interagency Task Force on Environmental Cancer and Heart and Lung Disease, Committee on Public Education and Communication.

Enders, J. (2001). Measuring community awareness and preparedness for emergencies. Australian Journal of Emergency Management, 16(3), 52-59.

Filderman, L. (1990). Designing public education programs: a current perspective. In: Handmer, J., and Penning-Rowsell, E. (eds.) Hazards and the communication of risk. Gower Technical.

Gill, J. C., & Malamud, B. D. (2014). Reviewing and visualizing the interactions of natural hazards. Reviews of Geophysics, 52(4), 680-722.

Höppner, C., Buchecker, M., & Bründl, M. (2010). Risk communication and Natural Hazards. In: C.-N. Consortium (Ed.) CapHaz-Net - Social Capacity Building for Natural Hazards - Toward More Resilient Societies, vol CapHaz-Net WP5 report, Birmensdorf, Switzerland, p. 169.

Kelman I. (2014). Disaster mitigation is cost effective. Background note for the World Development Report. CICERO, Norway.

Lester, P. (2013). Visual communication: Images with messages. Cengage Learning.

Lundgren, R., & McMakin, A. (2004). Risk communication - A Handbook for communicating environmental, safety and health risks. Battelle Press, Colombus, USA.

McCallum, D.B. (1995) Risk Communication: a tool for behaviour change. In: Backer, T.E., David, S.L., and Saucy, G. (eds.) Reviewing the behavioural science knowledge base on technology transfer. NIDA Research Monograph 155.

Neresini, F., & Pellegrini, G. (2008). Evaluating public communication of science and technology. Handbook of public communication of science and technology, 237-51.

Nicholson-Cole, S.A. (2005) Representing climate change futures: a critique on the use of images for visual communication. Computers, Environment and Urban Systems, 29, 255-273.

Renn, O. (2005). Risk Governance – Towards an integrative approach. White Paper. International Risk Governance Council.

Rohrmann, B. (1992). The evaluation of risk communication effectiveness. Acta Psychologica, 8,169-192.

Rohrmann, B. (1998). Assessing hazard information/communication programs. Australian Psychologist, 33(2), 105-112.

Schwarzenegger, A., & Renteria, H.R. (2006). Risk communication guide for state and local agencies. California Governor's Office of Emergency Services. pp.87.

Small, S. A. & Uttal, L. (2005). Action-oriented research: Strategies for engaged scholarship. Journal of Marriage and Family, 67(4), 936-948.

Smith, K. (2013). Environmental Hazards: Assessing Risk and Reducing Disaster. Routledge.

Swiss Re, (2017), Natural catastrophe and man-made disasters in 2016: a year of widespread damages, Sigma, No 2/2017.

UNISDR – United Nations International Strategy for Disaster Reduction Secretariat. (2007). Hyogo Framework for Action 2005–2015: Building the Resilience of Nations and Communities to Disasters. Extract from the final report of the World Conference on Disaster Reduction (A/CONF.206/6)

UNISDR – United Nations International Strategy for Disaster Reduction Secretariat. (2009). UNISDR terminology on disaster risk reduction. Geneva, Switzerland.

UNISDR – United Nations International Strategy for Disaster Reduction Secretariat. (2015). Sendai Framework for Disaster Risk Reduction 2015–2030.

UNISDR – United Nations International Strategy for Disaster Reduction Secretariat & UNGA - United Nations General Assembly. (2016). Report of the open-ended intergovernmental expert working group on indicators and terminology relating to disaster risk reduction.

2. Flood risk communication - Visualization tools and evaluations of effectiveness

This chapter is based on the following conference paper: Charrière, M.K.M., Junier, S.J., Mostert, E., & Bogaard, T.A. 2012. Flood risk communication – Visualization tools and evaluations of effectiveness. Proceedings of the 2nd European Conference on FLOODrisk Management, November 20-22, 2012, Rotterdam, The Netherlands.

2.1 INTRODUCTION

2.1.1 Communication for Disaster Risk Reduction

The increasing attention to disaster risk reduction is reflected by the creation in 2005 of the Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disaster (UNISDR, 2007). This framework acknowledges that vulnerability to disasters is increasing, among others due to demographic changes, urbanization, environmental degradation and climate change. This poses a threat to the world's economy, and its population and the sustainable development of developing countries. Examples such as the Katrina hurricane in 2005 and the tsunami disaster in Japan in 2011 show that this is also true for developed countries.

In the risk management cycle, communication is a key instrument for managing the consequences of disasters. It is important in the prevention phase but even more so in case of a crisis. Communication can influence the response of all parties concerned and, in that way, help decrease damage and save lives.

Risk communication mainly aims to raise awareness, change behavior of the stakeholders (exposed people, experts and managers, authorities, general public and media), enable dialogue (Höppner et al., 2010) and improve knowledge. Risk communication can be oral, textual or visual. Our study focuses on the latter. We define visual risk communication as a process of sending and receiving risk information with a significant visual component (e.g. Trumbo 1999).

Visual communication can be implemented through a wide range of means: pictures, movies, charts, graphics, maps or objects such as flood marks as well as newer technologies such as Geographic Information System (GIS), web-based platforms and smartphone applications.

Visualization has become an important topic of research in the last decade due to the increasing size of data sets produced by the most recent data acquisition techniques (Post et al., 2002). Due to increasing computing power, this has led to the emergence of new research fields such as ‘Information Visualization’ and ‘Data visualization’ (Post et al., 2002).

2.1.2 Objectives

The objective of this paper is to provide an overview of existing visual flood risk communication practices and to draw lessons for future use of visuals. We focus specifically on maps because they represent most of the practices and approaches that were inventoried and scientific results of risk assessments are often presented using maps. Moreover, the EU Flood Risk Directive (2007/60/EC) requires the creation of flood hazard and risk maps. Although the main hazard that we are interested in is floods, we have included other natural hazards in our inventory because we can learn from the field of other natural hazards as well.

After a brief explanation of the methodology, we present the results of the inventory of visual risk communication instruments. Subsequently we zoom in on maps. Then we continue with an overview of the evaluations of visual communications. We conclude that visual communication is well developed in some field but not in others and that there is a lack of evaluations of the real impact.

2.2 METHODOLOGY

2.2.1 Data Collection

For this paper, we first collected concrete risk communication practices, using the review of risk communication efforts produced by Höppner et al. (2010). In addition, we searched for communication efforts on the Web and in the academic literature, using combinations of relevant keywords, e.g. “risk communication”, natural hazards”, “flood”, “earthquakes”, etc. Combined with the snowball method, this resulted in approximately 500 scientific articles and a few websites on the general topic of risk communication. Secondly, we subsequently scanned for their relevance for this paper. This resulted in the selection of 31 risk visualization practices. Thirdly, we zoomed in on flood risk mapping practice and research. For this we relied on the scientific literature. And fourthly, we reviewed the examples of evaluation of the effectiveness of visualization for risk communication. These too were found in the scientific literature. Hence, we did not include internal evaluations.

2.2.2 Data Analysis

The data were analyzed using the framework for risk visualization developed by Eppler & Aeschimann (2009) (Figure 2.1). We focused on the purposes of the risk communication, the contents of the message communicated, the target groups of the message, the phases in the risk management cycle in which the communication takes place (prevention, preparedness, response, recovery), and formats or visualization means used.

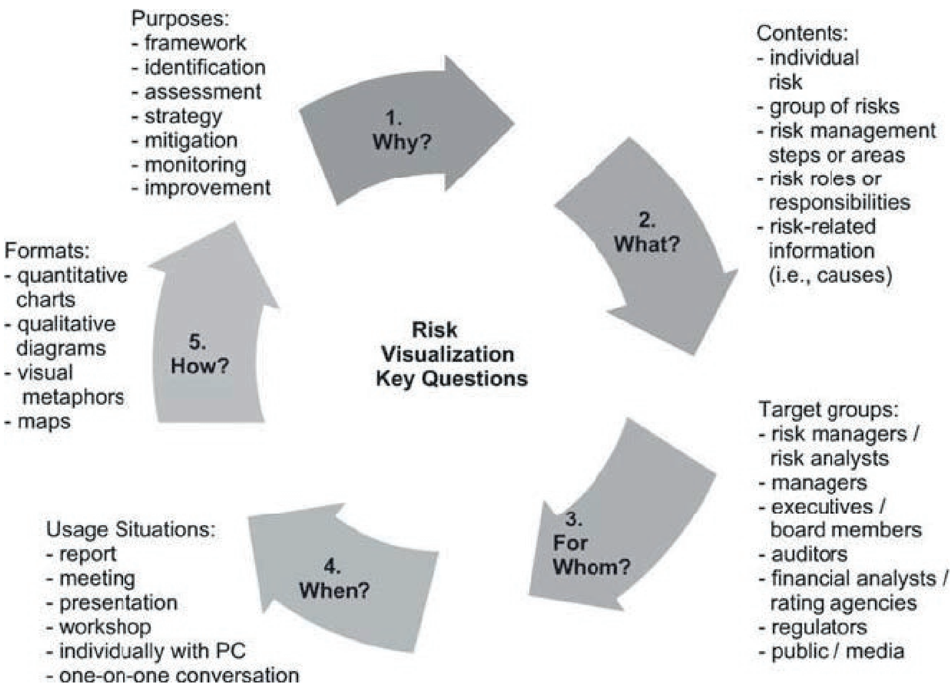


Figure 2.1: Key questions of the risk visualization framework. From Eppler & Aeschimann (2009).

2.3 VISUAL RISK COMMUNICATION PRACTICES

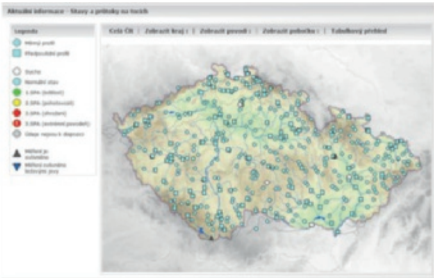
In total, 31 risk visualization practices were collected (Table 2.1, Figure 2.2). Fifteen of these concern floods only, while 4 are related to snow avalanches. Other natural hazards included are storms, hurricanes, fog, cold and heat waves, hail, snow falls, landslides, earthquakes, volcanic eruptions, tsunamis, surges, droughts and forest fires. Twenty-three of the 31 practices focus on one type of natural hazard only, while the other eight refer to – in principle – all natural hazards in the relevant area (e.g. the Austrian Weather Warnings Portal - Österreichische Unwetterzentrale).

Practice	Keywords	Webpages of the risk communication practice (if available)
Flood forecasting Service - Czech hydrometeorological Institute	Floods - map - web	hydro.chmi.cz/hpps/
Flood Information Service - Hochwassernachrichtendienst	Floods - map - web	hnd.bayern.de
Flood Portal - Baden-Wurttemberg	Floods - map - web	hvz.baden-wuerttemberg.de/
Flood Portal - HSK Koln	Floods - map - web	hw-karten.de/koeln/
Five-days flood forecasting - Environment Agency England	Floods - map - web - five days forecasting	flood-warning-information.service.gov.uk/5-day-flood-risk
Flood Portal - Environment Agency England	Floods - map - web	maps.environment-agency.gov.uk/ (link inaccessible in 2018)
Flood Portal - Scottish Environment Protection Agency	Floods - map - web	http://map.sepa.org.uk/flood map/map.htm
Risk Portal - Netherlands	Floods - map - web	risicokaart.nl/
Hochwasserschutz Regensburg	Floods - map/marks	hochwasserschutz-regensburg.de/stele.html
Austrian peak discharge information system	Floods - map -tv	
Plan Vidourle	Floods - marks	
Flood video - Terre.tv	Floods - video clip - web	terre.tv/

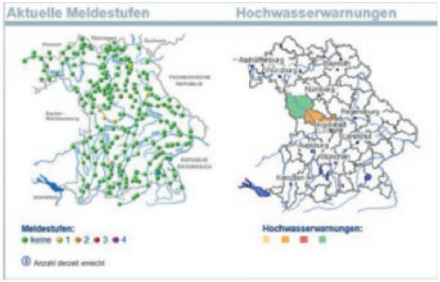
Table 2.1: Collected visual risk communication practices. Webpages last accessed on the 29 Jan 2018.

Flood cartoons Roo Su Flood	Floods - cartoons - web	youtube
River-Works	Floods - sculptures	
Documentary - Malborghetto-Valbruna municipality	Flash floods - documentary - dvd	
Snow avalanche Portal - Österreichische Lawinenwarndienste	Snow avalanches - map - web	lawine.at
Snow avalanche bulletins - Institute for Snow and Avalanche Research SLF	Snow avalanches - map - web	slf.ch
White Risk - Institute for snow and avalanche resarch SLF and SUVAlife	Snow avalanches - map - smartphone	
im Banne der Lawinen	Snow avalanches - documentary - dvd	
North Carolina Coastal Hazards Decision Portal	Storm surges - map - web	coastal.geology.ecu.edu/NCCOHAZ/ (inaccessible on 29 Jan 2018)
Severe weather warnings - MetOffice UK	Weather - map - web	metoffice.gov.uk/weather/
Graphical Tropical Weather Outlook - National Hurricane Center	Hurricanes - map - web	nhc.noaa.gov/gtwo.php
US National Drought Mitigation Center	Droughts - map -web	droughtmonitor.unl.edu/
Weather Warnings Portal - Osterreichische Unwetterzentrale	Multi-hazards - map -web	uwz.at
Multi-hazards Portal eHora	Multi-hazards - map -web	hora.gv.at
Prim.net Portal (Photothèque/Aleas.tv)	Multi-hazards - pictures/videos - web	
PREVIEW Global Risk Data Platform	Multi-hazards - sharing platform - map - web	preview.grid.unep.ch
Swiss Common Information Platform For Natural Hazards (GIN)	Multi-hazards - map - sharing platform	
GeoAnalytics Visualization (GAV) toolkit	Multi-hazards - map - sharing platform	
Geohazard maps - Filipino Mines and Geosciences Bureau	Multi-hazards - map -web	gdis.mgb.gov.ph/mgbpublic/
Stop Disasters UN/UNISDR	Multi-hazards – game (map) - web	stopdisastersgame.org

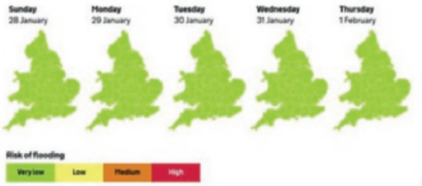
Table 2.1: Collected visual risk communication practices. Webpages last accessed on the 29 Jan 2018. (continued)



Flood forecasting Service - Czech hydrometeorological Institute



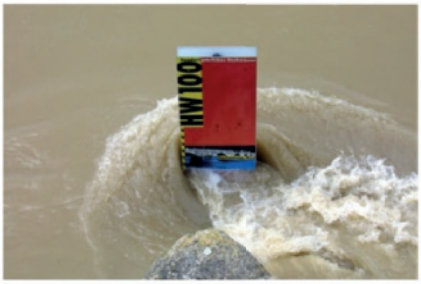
Flood Information Service - Hochwassernachrichtendienst Bayern



Five-days flood forecasting maps - Environment Agency England

Flood Portal - HSK Koln

Risk Portal – The Netherlands

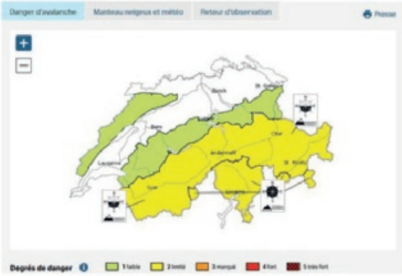


Flood marks - Hochwasserschutz Regensburg

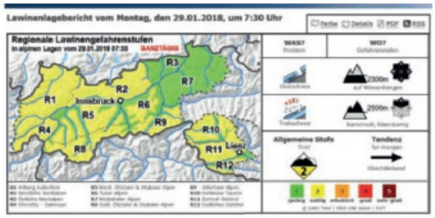
Flood cartoons - Roo Su Flood

Flood video - Terre.tv

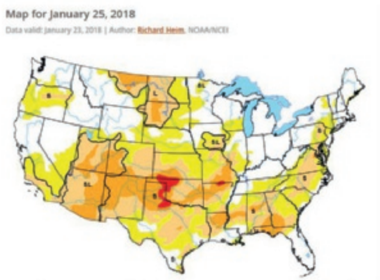
Figure 2.2: Selected practices among the 31 studied in this chapter.



Snow avalanche bulletins - Institute for Snow and Avalanche Research SLF



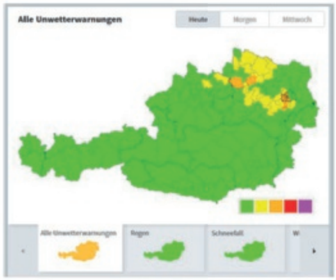
Snow avalanche Portal - Österreichische Lawinenwarndienste



Drought map - US National Drought Mitigation Center

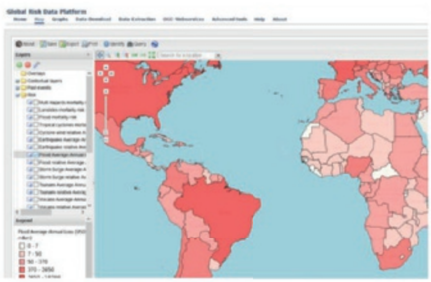
Graphical Tropical Weather Outlook - National Hurricane Center

Multirisk Portal - eHora



Weather Warnings Portal - Osterreichische Unwetterzentrale

Stop Disasters Game - UN/UNISDR



PREVIEW Global Risk Data Platform

Figure 2.2: Selected practices among the 31 studied in this chapter. (continued)

2.3.1 Purposes (Why?)

The purposes of the communication practices are usually not explicitly stated and often not easily distinguishable. Nevertheless, different purposes can be discerned. The main purpose is commonly to raise awareness and inform about natural hazards. In some cases, these purposes are combined with warning (e.g. Hochwassernachrichtendienst Bayern) and/or inducing protective behavior (e.g. WSL Institute for Snow and Avalanche research). Some communication practices have a special purpose, such as keeping memories alive (e.g. Flood sculptures, Höppner et al. (2010)) or sharing information (e.g. The PREVIEW Global Risk Data Platform, Giuliani & Peduzzi (2011)). However, none have the purposes suggested by Höppner et al. (2010): reassurance, improved relationships (build trust, cooperation and networks) and stakeholder involvement in decision-making.

2.3.2 Content (What?)

The content of the communication practices varies a lot, but they often provide information on the lev-el of danger (e.g. snow avalanche danger: the Österreichische Lawinenwarndienste), of risk (e.g. flooding risk: the English Environment Agency), of susceptibility (e.g. flood susceptibility: Mines and Geosciences bureau of the Department of Environment and Natural Resources of the Republic of Philippines), of warning (e.g. Österreichische Unwetterzentrale) or of river discharge (e.g. Hochwassernachrichtendienst Bayern). Especially concerning flooding, information is often given on the spatial extent of the hazard (e.g. Koln Hochwassergefahrenkarten) or actions to take (e.g. video clips on floods in Bangkok, Roo Su Flood).

2.3.3 Target Groups (for Whom?)

The large majority of the communication practices (22 of 31) are Web-based and can be accessed by anyone with an Internet connection. This suggests that the targeted audience is the general public. However, given the specific content, we can assume that the actual target group is the public at risk. The communicators are experts, institutions or authorities. The fact that nearly all practices found target the general public is probably due to the fact that the practices targeting others audiences are not public.

Only three practices targeting other audiences, such as experts, decisions-makers, authorities or institutions, were found. These are the Swiss Common Information Platform for Natural Hazards (GIN) (Heil et al., 2010), the PREVIEW Global Risk Data Platform and the GeoAnalytics Visualization (GAV) toolkit (Jern et al., 2010). Moreover, only these three practices have the special purpose of sharing information. Risk communication targeting the general public is usually treated as a one-way process, despite the importance that some authors attach to two-way communication, e.g. Höppner et al. (2010).

2.3.4 Phases of Risk Management (When?)

The phases of risk management in which the communication takes place are mostly prevention and preparedness. The majority of the cases (27 on 31) concern only one phase, e.g. the communication of flood warning for preparedness and the representation of flood extents for prevention. Only four practices aim to provide information for both prevention and preparedness. For example, in the case of the North Carolina Coastal Hazards Decision Portal, flood risk maps are available along with a map of real-time coastal hazards. This shows that using the same communication means can serves different phases of the risk management cycle.

2.3.5 Means (How?)

The map is undoubtedly the visual means that is most commonly used in visual risk communication (24 of the cases; see the next section). Other visual means identified include video clips, pictures and objects such as flood marks or sculptures.

2.4 RISK MAPPING

From the inventory of visual risk communication practices, we observed that maps are the most used visual means. Like other visual means, they can have different purposes, contents and target groups and can be used in different phases. Maps can be either static, such as the Flood susceptibility maps of Philippines' provinces, or dynamic, allowing interactivity. For instance, users could zoom in and out (e.g. Indicative river & coastal flood map of the Scottish Environment

Protection Agency), or choose different layers of information (e.g. Dutch risk web-portal Risicokaart).

2.4.1 Purpose (Why?)

According to Dransch et al. (2010, p. 294), 'natural hazards have a strong spatio-temporal component' and therefore maps of any type can improve awareness and understanding of risks. Based on this, they specify a large variety of potential objectives of maps: to improve risk perception (increasing knowledge and understanding, enabling appropriate risk assessment, allowing information accessibility), to support personal risk framing (creating a personal view, allowing confirming information with others through interaction) or to establish credibility (informing objectively or giving consistent information). Their study goes a step further by integrating findings from psychology and social sciences to propose a frame for cartographic principles in terms of objectives, tasks, and suitable map application and design.

If the study of Dransch et al. (2010) is a demonstration of the interest of research in the use of risk maps for communication, this is also highlighted by the applied field and in particular by the legislation. At the European level, it is emphasized by the fact that the development of flood hazard and risk maps is required by the EU Flood Directive (2007/60/EC). Although the primary objective of the maps is to be 'a basis for flood risk management plans' (Kellens et al., 2009, p. 2), another requirement of the Directive is to make the flood maps 'available to the general public' (Hagemeier-Klose & Wagner 2009, p. 564). This reflects that 'cartography can play an important role in communicating flood risks' (Kellens et al., 2009, p. 2).

2.4.2 Content (What?)

In theory, the contents of risk maps can differ widely: probability of hazards; exposure; vulnerability and potential harm to people, built environment and physical environment; or capacity to recover from such an impact (Cutter 2008). In practice concerning floods, this variety cannot be observed.

Studies by van Alphen et al. (2009), de Moel et al. (2009) and Kellens et al. (2009) show that, in Europe, flood hazard maps showing parameters such as flooding probability, extent and depth are much more developed than flood risk maps including potential damage or evacuation maps. If flood extent maps are available for the large majority of the European countries, only seven of them developed risk maps (qualitative risk: France, Switzerland, Spain and Italy; and quantitative risk: Flanders, Germany and Croatia). This shows the amount of work that has still to be done to meet the requirements from the EU Flood Risk Directive. The effects of flood defenses and climate change and uncertainty are usually not represented (de Moel et al., 2009).

Since "flood risk" can be interpreted in different ways, it is important to be clear to prevent misinterpretation and misunderstanding. An explicit code of practice may be useful in this respect (Moen & Ale 1998).

2.4.3 Target Groups (for Whom?)

The choice of target groups determines the type of map that is required. However, the review by Dransch et al. (2010) of the current state of research in the field of maps in risk communication shows that differences in target groups are rarely taken into account. Most studies discuss only maps for risk managers and authorities, while the use of maps directed to the public is rarely studied. Interestingly, this is in contrast to the predominance of communication with the general public found in the inventory of current practice. An exception is Kellens et al. (2009) who do discuss the use of maps to communicate risks to the public. They assume that, due to the spatial dimension of floods, maps are ideal for this purpose and audience.

2.4.4 Phases of Risk Management (When?)

While maps are clearly of use in different phases of risk management the literature found makes no explicit distinction between the phases. However, we can deduce that the existing risk maps are designed to be used in the prevention phase. For example, Dransch et al. (2010) categorize maps according to their purposes, but these are all are related to prevention.

2.4.5 Means (How?)

Maps consist of several components such as colors, background information and legend that have specific characteristics and purposes. All these components can influence ‘the effectiveness of the information transfer to the user’ (van Alphen et al. 2009, p. 290). The choice of the components (e.g. scale, basemap or geographic unit) depends on the purpose of the map (general information, preventive information, assistance to negotiation and decision, crisis management and regulation) (Chesneau 2004). Risk perception, communication process and information presentation 'have not been considered systematically in the map design process' (Dransch et al. 2010, p. 295) in spite that they 'give indications on the design of effective media' (Dransch et al. 2010, p. 299). Moreover, Chesneau (2004) encourages further research and design solutions as risk mapping still presents limits due to a partial exploitation of the graphical semiology and to issues related to superposition of information and uncertainty representation.

2.5 INVENTORIES OF EVALUATION OF VISUAL COMMUNICATION PRACTICES

The effectiveness of visual communication practices can be defined as the degree to which the purpose or purposes of the communication has been met ("outcome evaluation": Rohrmann 1992, 1998). We consider visual communication practices to be effective if they result in a change in the target group's risk awareness, knowledge, beliefs or behavior.

In the literature, we could not find any evaluation of the degree to which the purpose or purposes has been met. Instead, the evaluations that could be found focus on audience, content and mean, or on the relations between those.

Haynes et al. (2007) provides an example of an evaluation in which different means are compared, i.e. aerial photographs, contour maps and 3D maps. They assessed the ability of inhabitants of the Montserrat Island to locate, orientate, identify and decode mapped information and to identify, interpret and understand volcanic hazard information. They observed that aerial pictures are more effective than 3D maps, which are better than contour maps, for conveying information. However, they did not assess the impact of this information on risk awareness, knowledge, beliefs or behavior.

Similarly, Bell & Tobin (2007) tested the relative effectiveness for communicating flood risk (actually flood probability) of three different probability descriptions (a 100-year flood, a flood with a 1 percent chance of occurring in any year, and a flood with a 26 percent chance of occurring in 30 years) and of a map showing the 100-year floodplain. Their study suggests that the map is approximately as good as the descriptions concerning the understanding of the uncertainty. In addition, the map contains relevant information to people living in flood prone areas.

The use of the 'return period' concept was investigated in two studies that focused on the relation between content and target group. Hagemeier-Klose & Wagner (2009) evaluated 50 flood maps and 3 web-mapping services by investigating experts and laypeople's specific needs. It is not surprising that experts and general public have different needs, as they have undoubtedly different levels of preexisting knowledge. More specifically, the authors observed that when targeting the general public, the content of the communication should be clear and easy to understand and that technical terms such as 'return period' should be replaced by simpler expressions, e.g. "very frequent flood event". This finding is confirmed by the evaluation of flood marks present on flood information tables in three German municipalities conducted by Hagemeier-Klose (2009). From these two studies, we can conclude that the experts framing (i.e. return period) should be translated in more understandable concepts when the general public is targeted. This users' requirement approach is based on the assumption that if they are taken into account, this would 'lead to an increased awareness and a heightening of knowledge about flood topics' (Hagemeier-Klose & Wagner 2009, p.567).

This assumption is similarly present in the studies of Spachinger et al. (2008) and Fuchs et al. (2009). In these studies, flood risks maps were evaluated by means of eye movements tracking crosschecked by a cognitive survey. They demonstrate that different readers (specialists, sensitized people and laypersons) have different map reading strategies and that the layout and level of detail of the maps influences their strategy. Hence, layout and level of detail may influence the transfer of information. The main result of the studies is a conceptual map (Figure 2.3) for enhancing risk communication and awareness building of the public. However, in their study they did not assess whether the information was truly understood or remembered or that awareness actually increased.

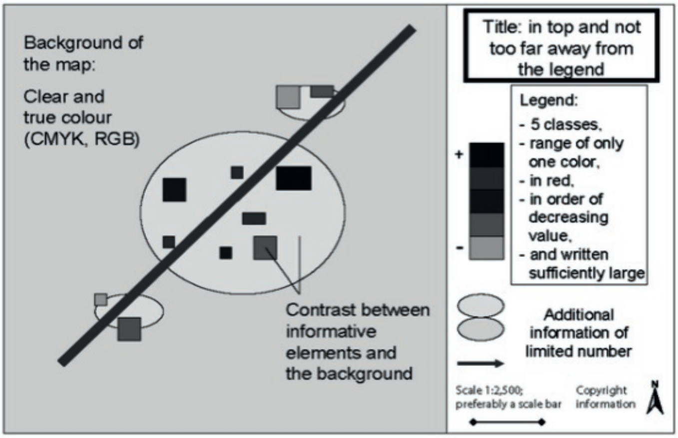


Figure 2.3: Conceptual map. From Fuchs et al. 2009.

In two studies users were asked to judge the appropriateness of the means. In Hagemeier-Klose (2009), experts and residents of three German municipalities were invited to evaluate flood marks. These showed either the boundary of the designated flood plain, the inundation depths of flood events with different occurrence probabilities, or the gauge levels of different discharges. In addition, the opinion of the opening ceremony's visitors on 15 flood sculptures (RiverWorks, Moosburg, Germany) was studied. The flood marks were viewed to be appropriate means of communication, but the addition of pictures of past events and the avoidance of technical terms could be beneficial. The only conclusion of the evaluation of the flood sculptures is that people saw them as an innovative means of communication.

The second example is the study of Flüeler et al. (2006). The authors conducted an evaluation of a slope stability web-application developed as a decision support system and a communication platform (Slope Stability on Nisyros Island (Greece)). Using standardized questionnaires, experts and lay persons were asked to evaluate the application according to usability, map design and interactivity criteria. It appeared that the participants were satisfied and considered the interactivity functions (moveable legends, spatial navigation tools, reference map and attribute display) to be useful to them. Again, the impact of these visuals was not evaluated.

In one study, map readability and the impact on decision-making and intended behavior was investigated. Kain & Smith (2010) conducted face-to-face interviews with North Carolina residents to assess the interpretation of hurricane advisory maps. They observed that people who interpreted the maps better thought that they would have time to decide whether to leave the area or stay. On the contrary, people who interpreted the maps less correctly said they would prepare to leave. Although the real change in behavior was not evaluated, the behavior that participants envisaged to have was. One can argue that that it is not sure that what people think they will do, is the same as what they will do in a real situation, especially a stressful one like an evacuation due to a dangerous event. Nevertheless, this study indicates that the use of visuals could have an impact on decision-making.

2.6 CONCLUSION

The inventory of current visual risk communication practices has shown that many are related to floods. The purpose of the communication practices was difficult to establish, but it appears that the aim is mostly to inform and warn. The content of the visual risk communication practices is highly diverse but usually covers the level of danger, warning or risk. The main target group is the general public. In a few cases decision-makers were targeted. The phases of the risk managed cycle covered are prevention, preparedness; response and recovery are not covered. Moreover, the most common means were maps, but many other means are used as well.

We can conclude from this inventory that visual communication is used quite extensively. The majority of the practices are maps aiming at informing the general public in the prevention or preparedness phases. However, visual communication aiming at other purposes, using other means, for other target groups and in other phases is less common, at least in the practices we found. Further developments of visuals could be profitable as we believe that risk communication should be as complete as possible in terms purposes, contents, audiences, phases and means in order to lead to an effective risk management. In this sense, we suggest that visual risk communication tools should be integrative, e.g. representing together multiple-phases information such as risk level, warning level and actions to take.

The review of flood risk mapping results in similar conclusions. Although in practice the use of risk maps seems to be more directed to the creation of risk management plans (as stated in the EU Flood Directive), maps can potentially support other risk communication purposes as well. At this stage, the use of risk maps for communication to the general public is not really considered in research. Flood risk maps are mostly designed for use in the prevention phase, but if additional information such as effects of protective measures or evacuation roads was included, the risk maps could be used for communication in preparedness and response phases. We can also imagine that development of real-time flood risk mapping could serve crisis management as it would make it more effective and hence reduce consequences of a disastrous event.

No published evaluations of visual risk communication practices exist that assess the ultimate impact in terms of risk awareness, knowledge, beliefs or behavior. The examples of evaluations in this review focus on users' requirements, ability to read the communication means, ability to understand the content, or satisfaction with the diverse components of the tool(s).

We can conclude that there is a big need for more research on the effectiveness of visual risk communication in terms of risk awareness, knowledge, beliefs or behavior. A good method for this would be to compare the situation prior and after the dissemination of the visual communication, as has been done by Lee & Mehta (2003) concerning blood transfusion risk communication. Their methodology, consisting basically in a pre-test, the dissemination of the message and a post-test with several groups, could be adapted to assess visual flood risk communication. Other types of experiment designs, such as games or evacuation exercises, could also be considered to assess the effectiveness of visual risk communication. Such designs would be especially useful to assess crisis' behavior as they simulate real life situations.

2.7 REFERENCES

Bell, H.M. & Tobin, G.A. (2007). Efficient and effective? The 100-year flood in the communication and perception of flood risk. Environmental Hazards 7(4), 302-311.

Chesneau, E. (2004). Propositions pour une cartographie du risque. Bulletin du Comité Français de Cartographie 181, 50-70.

Cutter, S. (2008). Keep representations simple for effective communication. In A. Bostrom, St. French & S. Gottlieb (eds.), Risk Assessment, modelling and decision support: strategic directions, 311-312. Berlin/New York: Spring-er.

de Moel, H., van Alphen, J. & Aerts, J.C.J.H. (2009). Floods maps in Europe – methods, availability and use. Natural Hazards and Earth System Sciences 9, 289-301.

Dransch, D., Rotzoll, H. & Poser, K. (2010). The contribution of maps to the challenges of risk communication to the public. International Journal of Digital Earth 3(3), 292-311.

Eppler, M.J. & Aeschimann, M. (2009). A systematic frame-work for risk visualization in risk management and communication. Risk Management 11, 67-89.

European Environment Agency. (2010). Mapping impacts of natural hazards and technological accidents in Europe – an overview of the last decade. Technical Report 13.

Flüeler, I., Iosifescu, I., Neumann, A. & Hurni, L. (2006). Cartographic SVG applications as risk management support and communication platforms. In Proceedings of the Fourth International Conference on Geographic Information Science, Münster, Germany.

Fuchs, S., Spachinger, K., Dorner, W., Rochman, J. & Serrhini, K. (2009). Evaluating cartographic design in flood risk mapping. Environmental Hazards 8, 52-70.

Giuliani, G. & Peduzzi, P. (2011). The PREVIEW Global Risk Data Platform: a geoportal to serve and share global data on risk to natural hazards, Natural Hazards and Earth System Science 11, 53-66.

Hagemeier-Klose, M. (2009). Final report about the summative evaluation of the new developed information tools. Floodscan, Task 9M11/D9.

Hagemeier-Klose, M. & Wagner, K. (2009). Evaluation of flood hazard maps in print and web mapping services as information tools in flood risk communication. Natural Hazards and Earth System Science 9, 563-574.

Haynes, K., Barclay, J. & Pidgeon, N. (2007). Volcanic hazard communication using maps: an evaluation of their effectiveness. Bulletin of Volcanology 70(2), 123-138.

Heil, B., Petzold, I., Romang, H. & Hess, J. (2010). The common information platform for natural hazards in Switzerland. Natural Hazards, 10.1007/s11069-010-9606-6.

Höppner, C., Buchecker, M. & Bründl, M. (2010). Risk communication and natural hazards. CapHaz-Net WP5 Re-port, Swiss Federal Institute WSL.

Jern, M., Brezzi, M. & Lundblad, P. (2010). Geovisual analytics tools for communicating emergency and early warning. In M Konecny, S. Zlatanova, T.L. Bandrova (eds.), Geographic Information and Cartography for Risk and Crisis management: 379-394. Berlin/Heidelberg: Springer-Verlag.

Kain, D.J. & Smith, C.F. (2010). Risk perceptions and emergency communication effectiveness in coastal zones - preliminary findings on interpretations of weather related messages and maps. Report provided to the Director of the US National Hurricane Center.

Kellens, W., Vanneuville, W., Ooms, K. & de Maeyer, P. (2009) Communicating flood risk to the public by cartography. In Proceedings of the 24th International cartography Conference, 15-21 November 2009, Santiago, Chile.

Lee, D.H. & Mehta, M.D. (2003). Evaluation of a visual risk communication tool: effects on knowledge and perception of blood transfusion risk. Transfusions 43(6), 779-787.

Moen, J.E.T. & Ale, B.J.M. (1998). Risk map and communication. Journal of Hazardous Materials 61, 271-278.

Post, F.H. Nielson, G.M. & Bonneau, G.-P. (2002). Preface. In F.H. Post, G.M. Nielson & G.P Bonneau (eds.), Data Visualization: The State of art – Proceedings of the 4th Gadstuhl Seminar on Scientific Visualization: ix-x. Kluwer Academic Publishers.

Rohrmann, B. (1992). The evaluation of risk communication effectiveness. Acta Psychologica, 8,169-192.

Rohrmann, B. (1998). Assessing hazard information/communication programs. Australian Psychologist, 33(2), 105-112.

Spachinger. K., Dorner, W., Metzka, R., Serrhini, K. & Fuchs, S. (2008). Flood risk and flood hazard maps – Visualization of hydrological risks. In XXIVth Conference of the Danubian Countries. IOP Publishing.

Trumbo, J. (1999). Visual literacy and science communication. Science Communication 20, 409-425.

United Nations International Strategy for Disaster Reduction Secretariat (UNISDR). (2007). Hyogo Framework for Action 2005-2015: Building the Resilience of Nations and Communities to Disasters. Extract from the final re-port of the World Conference on Disaster Reduction (A/CONF.206/6).

van Alphen, J., Martini, F., Loat, R., Slomp, R. & Passchier, R. (2009). Flood risk mapping in Europe, experiences and best practices. Journal of Flood Risk Management 2, 285-292.

3. Smartphone applications for communicating avalanche risk information – a study on how they are developed and evaluated by their providers

This chapter is published as the following journal paper: Charrière, M. K. M. and Bogaard, T. A.: Smartphone applications for communicating avalanche risk information – a study on how they are developed and evaluated by their providers, Nat. Hazards Earth Syst. Sci., 16, 1175-1188, https://doi.org/10.5194/nhess-16-1175-2016, 2016.

3.1 INTRODUCTION

The practice of recreational mountaineering activities, such as backcountry and off-piste skiing, has increased significantly (Jamieson & Stethem, 2002; Tase, 2004; Harvey & Zweifel, 2008; Burkelijca, 2013). Unfortunately, every year people die in avalanches practicing these sports. The appropriate way to reduce the number of fatalities lies in forecasting and education (Harvey et al., 2013). However, the best forecast is worthless if it is not communicated and fully understood by the users (Burkelijca, 2013). Consequently, the question arises whether the current ways of informing recreationists about the dangers levels and the mitigation behaviors are effective. A literature review highlights that numerous papers presented in the proceedings of the regular International Snow Science Workshops deal with this topic in terms of form, content, use, suitability of avalanches bulletins and tools to disseminate them (Dennis and Moore, 1996; Conger, 2004; Tremper and Conway, 2006; Statham et al., 2010; Burkelijca, 2013; Johnsen, 2013; Klassen et al., 2013; Landrø et al., 2013; Valt & Berbenni, 2013). It shows that the avalanche experts' community is highly concerned with providing effective avalanche risk communication and that discussions of the best practices to adopt are still ongoing.

In the last years, several smartphone applications were developed to communicate avalanche risk. This is not surprising as the smartphone market is growing (IDC, 2015), and accessibility to the wireless mobile technology is increasing around the world. This makes smartphones interesting for disaster risk reduction communication.

Doubts are sometimes cast upon the effectiveness of avalanche education because changes in behavior are not achieved by providing information only (McCammon, 2004a). This argument can also be made concerning avalanche risk communication. Accidents continue to happen although major communication efforts have been undertaken by the European and North American avalanche centers. However, the appearance of these smartphone apps in the last years shows that the development of communication is considered useful and valuable.

Developing risk communication campaigns is resource-consuming and risk communicators want to make their communication efforts effective. Proceeding to a systematic evaluation of the effectiveness is therefore necessary. In the case of avalanche risk communication, and in particular using smartphone applications, no scientific research has been published. Before conducting an evaluation research of the smartphone applications dedicated to avalanche risk communication, it is important to assess how current practices are developed, what and how choices were made, what questions and challenges avalanche risk communicators face and how the apps' effectiveness is currently evaluated. This first step is needed for future research that would evaluate the effectiveness of the avalanche risk communication effort by smartphone apps. Therefore, this study aims to analyze how these apps are developed and evaluated by the persons and organizations providing them, based on semi-structured interviews with the developers of the smartphone applications for avalanche risk communication.

The interest of this work reaches beyond avalanche risk communication. It is interesting to focus on communication related to this particular hazard, as it is more advanced than communication related to other hazards. Avalanches are the only natural hazard for which, after long debates, an international standard for the dissemination of risk information was developed, i.e., the public avalanche danger scale. Consequently, the findings, lessons learnt limitations and recommendations derived from this work could be taken into account in future practices of risk communication covering other natural hazards.

3.2 METHODOLOGY

In order to describe the way smartphone applications disseminating avalanche danger information are developed and consecutively evaluated, semi-structured interviews were conducted via Skype during fall 2014 with the developers of six of the seven available smartphone apps which focus on avalanche risk (Table 3.1, Figure 3.1). All these apps are free to download and use. Those are the apps that provide avalanche forecasts and warning but that are not specifically developed for searching for victims or as an aid to risk assessment.

Interviewees were identified through the web pages of the smartphone applications. Snowball effect facilitated the process of access to the interviewees. The qualitative analysis presented here is based on the interviews' reports whose content was checked by the interviewees. No discourse analysis was undertaken because it is beyond the focus of our work. Observations derived from the use of the apps by the authors complete the interviews.

ID Number	**Smartphone application**	**Developer**
1	Avalanche Canada	Avalanche Canada
2	Utah Avalanche Center	Utah Avalanche Center
3	Avalanche Forecasts	Independent developer
4	White Risk	WSL-Institute for Snow and Avalanche Research SLF
5	Varsom	Norwegian Avalanche Center
6	SnowSafe	Independent developer

Table 3.1: Smartphone applications analyzed.

To address the way the smartphone apps were developed and evaluated, several parameters were taken into account in the analysis. They were chosen according to the pillars of risk communication (Höppner et al., 2010): (1) actors, (2) purposes, (3) modes, channels and tools that we combine into means and (4) message, as well as to risk communication evaluation research (e.g., Rohrmann, 1998). Consequently, we produced descriptions of

- the apps in terms of developers, content and mean;
- their development in terms of purpose, target audience, choices of content, visualization approach and tools as well as the place of the apps in a larger communication plan;
- the evaluation strategies implemented by the developers, i.e., users' feedback, usage, understanding, effectiveness.

Additional information about the apps were retrieved from the interviews and can be found in Table A1.1 in Annex A1.

3.3 THE SMARTPHONE APPLICATIONS

This chapter describes the six studied smartphone applications in terms of who developed them, what their content is and how it is presented in maps, icons and drawing, texts and terminology. Note that this description corresponds to the apps as they could be accessed during the winter season 2014–2015, unless specified otherwise.

Figure 3.1: Screenshots of four pages of App 1: Avalanche Canada, App 2: Utah Avalanche Center and App 3: Avalanche Forecast. They were made on the 01.26.2016 and on the 03.02.2016 on the versions of the Apps that are compatible with IOS 7.1.

Figure 3.1 continued: Screenshots of four pages of App 4: White Risk, App 5: Varsom and App 6: SnowSafe. They were made on the 26 Jan 2016 and on the 2 Mar 2016 on the versions of the Apps that are compatible with IOS 7.1.

3.3.1 Description of the Communicators

Apps 1 and 2 were commissioned by warnings services of North America and apps 4 and 5 by European ones. All the corresponding interviewees are avalanche experts. Apps 3 and 6 were created by smartphone apps developers by profession. They are not avalanche experts but are familiar with the topic as they are both recreational mountaineers and work for or in collaboration with the avalanche centers that are producing the data used in the apps they developed.

3.3.2 Description of the Content of the Apps

The smartphone apps contain several types of information (Tables 3.2–3.5) but the main content is the avalanche bulletin with the avalanche danger level. The international standard danger scale with five levels (low, moderate, considerable, high, extreme) is used and displayed. Apps 3, 4 and 5 provide an explanation of the danger scale. While app 3 provide links towards the websites of each considered forecast regions in order to get further information, the latter is included directly in the other apps. Apps 1, 2, 4 and 5 give more detailed information using the avalanche problems “concept”, i.e., the types that can occur given a set of conditions (Landrø et al., 2013) (Table 3.3). For apps 1 and 5, even though the danger level is the first information to be presented, the current avalanche problems get a central position in the bulletin as their characteristics are systematically reported next to icons (see Figure 3.2h for app 1 and Figure 3.1 for app 5). In apps 2 and 4, the avalanche problems are described in the text of the bulletin. In White Risk, their typology can also be accessed in the “about the bulletin” explanation tab. Moreover, in this last app, current danger patterns (avalanche-prone location in terms of slope aspects and elevation) are described similarly in app 6.

Additional information such as weather condition and snowpack information are standard in all apps. In one case (app 2), it is completed with information on road conditions, the emergency contacts, the users’ observations as well as the terms of use.

CONTENT		Avalanche Canada	Utah Avalanche Center	Avalanche Forecasts	White Risk	Varsom	SnowSafe
Danger level	By defined forecast regions			√		√	
	By forecast regions and by elevation zone	√					√
	By forecast regions, by elevation zone, by aspect		√				
	By homogenous zones				√		
Danger description		√	√		√	√	√
Validity period of the bulletin		√			√	√	
Current day bulletin		√	√	√	√	√	√
2 days forecast		√		√		√	
Confidence level of the forecast		√					

Table 3.2: Content available in smartphone applications: danger level and related information. √ indicates that the information is present in the given Smartphone application.

CONTENT	Avalanche Canada	Utah Avalanche Center	Avalanche Forecasts	White Risk	Varsom	SnowSafe
Avalanche prone locations (aspects/elevations)				√		√
Current avalanche problems	√	√		√	√	
Terrain and travel advice	√	√		√	√	√
Avalanche summary	√				√	

Table 3.3: Content available in smartphone applications: avalanche related information. √ indicates that the information is present in the given Smartphone application.

CONTENT	Avalanche Canada	Utah Avalanche Center	Avalanche Forecasts	White Risk	Varsom	SnowSafe
Snowpack summary	√			√	√	√
New Snow (1 day/3 days)				√		
Snow depth (total, at 2000m, at 2500m)				√		
Snowpack stability				√		
Measured data at stations for the last 3 days (wind, temperature, snow				√		
Current weather conditions	√	√		√	√	√
Weather Forecast	√	√		√		√

Table 3.4: Content available in smartphone applications: Snowpack and weather information. √ indicates that the information is present in the given Smartphone application.

CONTENT	Avalanche Canada	Utah Avalanche Center	Avalanche Forecasts	White Risk	Varsom	SnowSafe
Road conditions/traffic cams		√				
Inclinometer				√		√
Analyzer tool				√		
Risk reduction tool				√		
Tour planning tool				√		
Explanation danger level/scale			√	√	√	
Other explanations*				√		
Gear information	√			√		
Emergency contacts		√				
Users' observations	√	√		√		
"Tutorial" use of the app			√			
Terms and conditions/disclaimer	√	√	√	√		√

*(avalanche patterns, core zone publication time/validity, avalanche size, interpretation guide slab avalanche, safer six, slope angle, group composition, weather, warning signs, new snow, behavior)

Table 3.5: Content available in smartphone applications: Additional information. √ indicates that the information is present in the given Smartphone application.

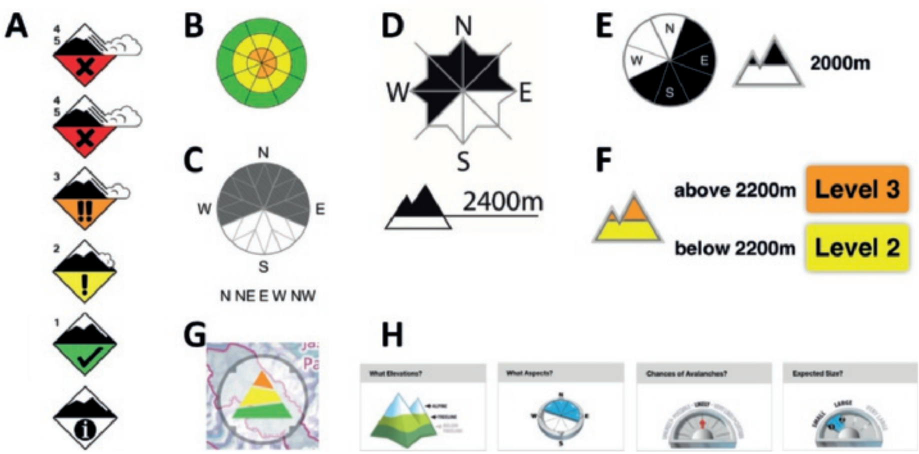


Figure 3.2: Icons used in the smartphones applications during the 2015-2016 winter season. (A) Avalanche danger scale used in apps 1, 3 and 6. (B) One icon to display danger levels according to elevation and slope aspects in app 2. (C) Slopes prone to avalanche in app 5. (D) The two icons used to inform on slope and elevation prone to avalanche in app 4. (E) Slope prone to avalanche icon in app 6. (F) Danger levels according to elevation in app 6. (G) Danger levels according to elevation in app 1. (H) Drawings used to characterize avalanche problems in app. 1.

3.3.3 Ways of presenting the information

Maps are often used to present hazard and risk information (Dransch et al., 2010) and much research has been conducted on maps' design for risk communication (e.g., Fuchs et al., 2009; Meyer et al., 2012). In relation to avalanche risk communication, online GIS and maps are used extensively (Conger, 2004). However, in the case of the six apps, the use of maps is not standardized. App 2 does not use this type of visual mean. App 1 uses maps for localization purposes and access to the regional bulletins. Apps 3, 4 and 5 display danger levels with colored polygons on a base map, while app 6 shows the icons of the international danger scale rather than the color on the polygons. In addition, to represent danger levels or to help for localization, additional use of maps is present in app 4. They are used to display snow related observation.

Several icons appear in the apps (Figure 3.2). The symbols of the avalanche danger scale (A) are used as a legend banner (app 3) to display the highest danger rating on the map (app 6) or in the bulletin (app 1, while icon G is used here on the map). A single icon (B) is used in app 2 to represent the danger ratings according to elevation and slope aspects. In app 5, icon C indicates the slopes prone to avalanches, while prone elevations are indicated next to it by mean of text (in the 2014–2015 version of the app, the icon also integrated elevation). Two separate icons (D) display this information in app 4. E and F icons are combined in app 6 to provide avalanche-prone slopes and danger level according to elevation. Finally, app 1 uses one icon (G) to show this latter information on the main page and various drawings (H) to display the characteristics of the current avalanche problems, i.e., the elevation, the aspects, the chances and the expected size.

Even though the smartphone applications have a major visual component, text is used quite extensively. Typically text is used as followed: (1) one sentence, placed at the top of the main page, describes the danger situation; (2) a few words are used in support of icons for the danger level (e.g., “moderate”), elevation/aspects repartition (e.g., “in all aspects above approximately 1800 m”) or avalanche problem (e.g., “naturally released”); and (3) extensive and elaborated text is used to explain detailed information on the current danger situation, the recent activity, the avalanche problems, the snowpack stability, the weather and/or the forecast tendency.

The term “danger” is used, whereas no occurrence of “hazard” was noticed. Reference to the “risk” term was only found in app 6, in the expression “risky expositions”. Note that in the app 1, there is no mention of any of those words. The bulletin and forecast are expressed only with the words linked to the different levels of the danger scale, e.g “considerable” or “moderate”. The likelihood of avalanche problems is expressed as “chances” with the terms “unlikely”, “possible”, “likely”, “very likely” or “certain” in app 1. In app 5, terms related to probability are used, for example “probable” or “low probability”.

3.4 DEVELOPMENT OF THE APPS

This chapter highlights the underlying processes and elements that determined the development of the apps: the purpose, the audience, the choices of content, visualization approach and tools as well as the place of the apps in a larger communication plan.

3.4.1 Purpose of Developing the Apps

The general purpose of developing those apps is to inform about avalanche risk by making use of the smartphone technology. In the opinion of the interviewees, its main advantage is the ease of access of information in terms of timing and location (e.g., when people do not carry their computer or when people are on recreational sites). This general purpose is common to all apps, but more specific purposes were mentioned as well by the developers that were interviewed, such as increase awareness and reduce the loss of lives (app 5), help users plan their trips (app 1) and retrieve users' observation (app 2). Moreover, in the case of the two apps developed by avalanches non-experts, the more specific reason for their development was that the developers wanted to fulfill their own needs. Being themselves recreational mountaineers, they wanted quick access to avalanche risk information using their smartphone.

3.4.2 Targeted and Actual Users

From the interviews, it appeared that the Swiss app (app 4) targets the general public in its totality, while the other apps were developed for recreational mountaineers (snowmobilers, off-track skiers, backcountry skiers) independent of their knowledge and skills. An additional user group was targeted by the app 5, i.e., road managers. App 6 was primarily developed for a young audience as they were the main users of smartphones at the time of development. The developer therefore chose a cartoonish look for the app, i.e., colorful with a little animal-like mascot. However, it is stated on the website that some parts of the apps were designed for "advanced users".

The actual users of the considered smartphone applications are not well known. None of the developers has a direct way to find out. One reason that was given is the lack of resources and expertise to carry out such a survey. However, it was sometimes mentioned that the actual users are probably the targeted ones. Moreover, some developers have clues about who are using their products. For example, the developer of app 6 knows that mountain guides are using it. A survey on the avalanche bulletin, which is displayed in app 4 but also on their website, showed that people accessing the bulletin are active backcountry tourers or free-riders (Winkler & Techel, 2014). Interest in gathering users' statistics was expressed by most interviewees. One action that was proposed is to analyze where the users come from and correlate this information with forecasting regions in order to get insights in the differences (e.g., of use, of opinion) between people living in those and the persons that do not.

3.4.3 Basis for Choice

When asked how the content of the apps was chosen, it was most of the time implicitly answered that the information displayed is "useful" for the users. Common sense was stated as one basis for the choices. In addition, requirements from the smartphones' operating systems were mentioned to have an influence (apps 2 and 4) as well as the opinions of the warning services (app 6).

Except for app 3, which only provides the danger level with links to avalanche warnings services' web pages, all the other applications were constructed around a pyramidal approach. When this was explicitly stated by the interviewees, the reason behind using this approach is that the most important information, i.e., the danger level, has to be presented first. The rest of the information is presented by going more and more into detail as tabs are accessed or as users scroll down. The term "tiered approach" was used by the interviewee of app 1. The associated reason is the need to address all potential users (with potentially a wide range of abilities and knowledge) rather than the importance of the information. This logic was also expressed by the app 5 interviewee. A perfect bulletin should address non-expert users with headlines, dangers levels, exposed area and avalanche problems only, while trained users need more detailed information in order to take decision about the "trip" they will take.

One given reason to display the danger level on a map is the fact that people do not want to read text and therefore using a visual is the best way to present the most important information. Moreover, it is believed that in this way a quick overview of the situation on a whole area is possible and can help for the planning of a trip. This perspective is not shared by all interviewees. In app 1, the map is only used for localization purposes and access to the regional bulletins. The reason given for not displaying the danger level by coloring the full forecast regions is that it would be a too serious simplification to make. Nonetheless, the danger levels appear on the map by the display of an elevation icon (G, see Figure 3.2). App 6 makes use of a map in a similar way: it is used to demarcate the forecast regions and display the overall danger with one of the icons of the avalanche danger scale, in order for users to get an overview and choose a region for their trip. Similar concerns linked to the difficulty and the danger associated to the aggregation of local information in a larger area resulted in the fact that app 2 does not present any maps.

3.4.4 Place in a Larger Communication Plan

The apps created by avalanche warning centers were not the only communication tools they used. They all have a website to communicate the bulletins, which was sometimes viewed as the most important communication tool that exists, the smartphone application only coming to support it. Other means of communication are social media, blogs, telephone and newspapers.

It is interesting to note that the Norwegian application (app 5) was built in a multi-hazard framework of risk communication. In addition to present avalanche bulletins, it shows the bulletins related to floods and landslides.

3.5 EVALUATION OF THE APPS

After concentrating on the ways the apps were developed, the interviews focused on how the developers proceeded to evaluate their apps. It appears that several types of evaluation were conducted and other ones were discussed with the interviewees.

3.5.1 Users' feedback

Possibilities for users to send a general feedback through the app are limited. App 6 has a form included in the app, which is said to be mostly used to report on technical problems or to ask whether the app is available for other regions. App 2 provides a direct link to send an email. However, other feedback possibilities exist. On the associated web page of app 5, it is possible to report when the bulletin was useful using a like/dislike button. In addition, it appears that the Avalanche Canada receives feedback by emails or phone.

Although opportunities for general feedback are not very extensive, the importance of another type of feedback, i.e. giving the users the possibility to share their observations on snow and avalanches conditions, is put in practice or acknowledged by most of the apps. The best example is in app 1. In addition to date, time, location and the possibility to attach a picture, people can report on skiing, snow, avalanches and weather conditions and they can add comments (details in Annex A1). Currently, the observations are not moderated as no inappropriate content has been posted so far. In future updates, incident reports will be possible as well as more detailed observations concerning avalanches, snowpack and weather.

Although the reporting of observation from the users is stated as one of the goals to develop the app, app 2 does not propose a similar form but provides a link to send observations by emails. There is also the possibility to take a picture with the app and to report it. However, the possibility to send more structured reports will be given in the future. At the time of the interviews (winter 2014–2015) observation forms were not available in apps 4 and 6, but they were planned. During the 2015/2016 season, they were introduced in app 4. There is no direct way to provide feedback using the Varsom application. However, observation feedback can be given using its twin app, regObs.

3.5.2 Usage Monitoring

Almost all applications have a technical monitoring of the usage. The metrics used, varying from app to app, are for example the number of downloads, number of people using the app and number of times specific features of the app were accessed. One interviewee stated that the latter is useful, for example, to assess whether there is a need to move or remove some features. At the time of the interview, the usage of app 5 was not yet monitored because it was launched for the first time that winter but its future inclusion was mentioned. Monitoring of the usage of both the apps and the website, which also provides avalanche warning information, will be compared to see whether the use of each of the tools is influenced by variables such as a given danger level or some specific weather conditions.

3.5.3 Understanding of Content and Visuals

Two of the six apps had been evaluated for content and presentation. App 1 had been evaluated during the design phase. Basis surveys had been conducted to assess what people understand/think when they see the information. It appeared that participants understood the different icons that were used and the representation of variation of danger level depending on the elevation. Moreover, risk communication experts were consulted on the ways to display the forecasts as well as on the use of icons and text.

The SLF (app 4) had performed a quality and usability evaluation by an internet survey in 2008 (Winkler & Techel, 2014). Note that this evaluation did not focus on the app in particular but on the bulletin that was displayed in both the website and app. Nevertheless, it induced a revision of the bulletin for both tools in 2012. This evaluation resulted mainly in the modification of the display of the bulletins according to the pyramidal approach favored by the European Avalanche Warning Services (EAWS, 2009). Danger pattern information (avalanche-prone location in terms of slope aspects and elevation) was therefore removed from the danger level information and placed in a separate "tab". Moreover, the interviewee reported that the way regions were described in the text of the bulletin was not always understood. Therefore, they were removed. Currently, the extent of the different danger levels is shown independently of any definition of regions. In 2014, a second survey allowed to assess the results of these modifications. Interesting results, in light of this work, are that the new way to inform about danger patterns is an improvement and that the large majority of the participants find the bulletin very important.

App 2 interviewee declared that a process that would allow to test the effectiveness of different ways to present the same information has started. Tests are planned to be conducted in collaboration with experts in people surveying. The use of a game environment in which people could choose, between different formats (3-D vs. 2-D, separate icons vs. combined icons), the ones they prefer or understand the best is considered.

App 5 had not been evaluated as such but previous users' surveys conducted for the website had an impact on the way information is displayed in the app. It appeared that users did not understand the complex drawings that were used to illustrate avalanche problems. Consequently, it has been decided that visuals would only be used for elevation and aspect information. At first, on the website, two distinct icons were used in order to ensure that users, mainly the Norwegians, would understand. The combination in one single icon (2014–2015 version of the app) was introduced because it is the way that most warning centers present such information and non-Norwegians are already used to this "standard" visual.

3.5.4 Effectiveness

Generally, the need to evaluate the effectiveness of the apps was acknowledged. Several goals for an evaluation, which was sometimes in the process of development, were proposed: satisfaction of the users, understanding of the information provided, remembering of the information, change in risk and danger perception, increase of awareness as well as change in behaviors. An indirect evaluation using the users' comments that can be written on the downloading websites (Apple Store, Android Store) was also mentioned.

Resources-related and methodological reasons were given to explain why such evaluations were not yet performed. Lack of expertise, funds and time constitutes the first type of reasons. Related to the second type, the increasing difficulty of truly evaluating the effectiveness from a satisfaction survey to an analysis of the change in behavior was mentioned. In this line of thought, one interviewee mentioned the need to conduct longitudinal surveys during several years in order to assess the changes in behavior.

3.6 DISCUSSION

The combination of elements and results presented in the preceding three chapters is discussed here to provide considerations of the information chain that is taking place through the apps, of the appropriateness of the chosen content, of the fact that visuals are not used uniformly, of the reasons why the apps were developed, of the target audience and the associated representation approach as well as of the way the developers assess the effectiveness of their product.

3.6.1 The information Chain

The communication chain of the considered smartphone applications takes place either between warning services and users (apps 1, 2, 4 and 5), i.e., via direct information flow, or between application developers, who use the information from the warning services to feed their app (apps 3 and 6), and the users, i.e., via indirect information flow. In the first case, the apps were created to use the intrinsic benefits of this technology and thus as an extension of the existing websites. Concerns about the way avalanche information is best communicated did not start with the development of this mean of communication nor did they disappear with its use. The interviews did not reveal that the development of these apps is part of a clearly defined communication strategy. However, being multi-hazards (avalanches, floods and landslides), the Varsom app is taking part in a larger communication plan that aims at informing the public on all the major natural hazards occurring in Norway.

The indirect flow of information (apps 3 and 6) is due to the need to fulfill personal needs as well as having expertise in smartphone technology. The fact that the developers are not the creator of the information could theoretically be seen as a threat to correctness of information and an open door to the dissemination of false messages. However, this is prevented by the use of information directly from the source, i.e., the warning services that collaborate with the developers. Added to the fact that the information provided by the apps is relatively basic, this type of communication chain, with involvement of external parties, is thus reliable. This indirect information flow is possible because the data are open access (in one case under signed agreement) and because no legal constraints exist on the way avalanche danger information should be communicated (see Annex A1). Nevertheless, most developers protect themselves from any legal action from users by adding a disclaimer at the start page of their app.

The willingness of the warning center to share their data as well as the unconstrained legal context are favorable conditions for the involvement of external parties with risk communication expertise. Even though the latter were sometimes consulted, the interviews did not reveal that communication experts were directly involved in the development or evaluation of the apps. However, following the opinions of some of the interviewees, we believe that a systematic involvement of risk communication specialists could increase the effectiveness of such communication tools.

3.6.2 Appropriateness of content

The central content of all described apps is the avalanche danger level. For all apps, this information is disseminated using the avalanche danger scale. This instrument, the purpose of which is risk communication (Statham et al., 2010), is now, after years of debates and development (Dennis & Moore, 1996), the standard to communicate avalanche conditions and forecasts. This shows that the development of the smartphone apps is basically a logical continuation of the existing avalanche risk communication framework. The use of smartphone technology did not trigger a major change in the information that was already communicated using other communication tools. This means that the information at stake is easily transferrable from one platform to another and that the apps are not seen as a really different communication tool. It seems to be perceived as another type of “computer screen” on which the same danger information can be displayed. However, differences can exist in the effectiveness of each type of communication tools. For example, in relation to the accessibility, the use of a mobile website compared to an app is more inclusive and therefore maybe more suitable to target as many people as possible, as there is no issue related to the operating system or type of device. Therefore, evaluation and comparison studies are a must to verify whether smartphone applications are as effective to communicate information as other communication tools and, if not so, what content adjustments should be made.

The fact that the use of smartphone app is the logical continuation of how the avalanche centers communicate about avalanche risk – mostly using websites – can explain why answers to the question of how the choice of content was made were hard to obtain. The interviewees seemed puzzled by this question. It seems therefore that the reasoning behind this choice is somehow implicit or following common sense, as said by one of the interviewees. This, as well as the fact that the content of the apps is largely similar to what is presented in the websites, suggests that there is no debate about what is the most important information to disseminate in effective avalanche prevention communication. It is interesting to note that the avalanche communicators' community has a very strong opinion on what the most important information to disseminate is for prevention while it is not always clear what is the most effective information to disseminate in order to achieve disaster risk reduction of other natural hazards. However, avalanche communicators should not forget that the message they provide might be new to some users and that some explanation is required. Indeed, only three applications provide a description of the avalanche danger scale. However, whether the absence of explanation has an impact on the understanding of the bulletin by various users is still unexplored.

As a matter of fact, previous knowledge, ability to understand and needs of potential users are elements that must be considered to ensure effective risk communication. This is especially the case when the information is ample. In addition to the avalanche danger scale, two-thirds of the apps present "avalanche problems" (see Sect. 3.3.2). Those are considered to assist in decision-making (Atkins, 2004 from Klassen et al., 2013; Landrø et al., 2013) as they can help recreationists choose the area to go to and techniques to avoid danger (Klassen et al., 2013). Avalanche problems can help understand local conditions while danger levels give information on the extent of the issue (Landrø et al., 2103). In other words, danger levels help raise awareness while avalanche problems are risk mitigation information (Klassen et al., 2013). Even though risk mitigation was not specifically stated as one of the purposes of the apps which do include avalanche problems, it is implicit that they were designed in this line of thought. Note that risk mitigation can be addressed using means other than avalanche problems. App 4 proposes a wide range of tools (e.g., situation analyzer, risk reduction method) to help decision-making. Consequently, there is a need to pursue the effort started by Landrø et al. (2103) of evaluating the use of avalanche problems as a risk mitigation tool for different types of audiences (e.g., experts and lay persons).

3.6.3 Non-uniformity in the Use of Visualization Tools

While the use of the avalanche danger scale is not under discussion, not all its components are uniformly used. Its icons (Figure 3.2a) are only used in 3 of the 6 apps (ID 1, 3 and 6). App 4 uses a different color scheme for level 5 (black/red checked pattern instead of black). In addition, travel advices, which are one of the components of the avalanche danger scale, can be found in the textual explanation of the danger situation in all apps (except app 3). They are only systematically presented in avalanche problem sections in apps 1 and 5. Finally, non-uniformity in the use of maps or aspect/ elevation icons is an illustration that the current debate among avalanche experts focusses on the representation of the forecast and related information rather than on the content to disseminate or the terminology to use.

Uniformity in terminology is taking place. The term “danger” is used in all apps, while “risk” and “hazard” terms are not used. Similarly, the level terms of the avalanche scale (e.g., considerable) are the same in all apps. As explained by Dennis and Moore (1996), the debate about which terminology to use took place in the 1990s and the observed uniformity of terminology used in the smartphone applications shows that avalanche experts have reached an agreement on that point.

3.6.4 Reasons to Develop an App

The primary purpose of creating these apps is to take advantages of the smartphone technology, e.g., popularity and mobile network spatial coverage. These are good reasons as using a support that is popular can favor access to information. Moreover, the portability of smartphones tackles the issue of overlooking some details or forgetting the bulletin that was checked in the morning while being out in the field, a problem that even seems to happen to the most educated professional (Tremper, 2006). However, this purpose is not one on which a communication effort can be assessed to be effective or not in terms of disaster risk reduction. The effectiveness of a given risk communication effort, similarly as for an educational program, depends on the goal for which it has been developed (Covello et al., 1991; McCammon, 2004a). Such types of goal, like raising awareness or helping users to plan trips, were mentioned by interviewees, although generally after reference to the technical goal of using the smartphone technology. Note that only once was the decrease of loss of lives stated as the goal for creating such apps. It is startling as this goal can be expected to be the ultimate one for avalanche risk communication. One reason that could explain why this purpose is not mentioned by all communicators might be in that it is now known that the reason for being caught in an avalanche is most of the time not lack of awareness, knowledge or expertise but rather heuristics (McCammon, 2004b).

3.6.5 Target Audience and Tiered Approach

This analysis shows that the smartphone applications are targeting a more or less defined audience, from general public to a more precise group, i.e., backcountry mountaineers. There is clearly a need to target the latter as most accidents involve them or off-track skiers (Harvey et al., 2013). However, the targeted audience is perceived to be heterogeneous in terms of several variables, e.g., level of skills and knowledge or demographical characteristics such as age. Differences between experienced/trained and unexperienced/untrained users are acknowledged and taken into account by the way the information is presented, i.e., pyramidal or tiered approach. Using this approach allows to avoid simplifying the message/content too much and meet the needs of such a broad audience, i.e., provide the most important information first for lay users and at the same time give useful details for more advanced users. Demographical characteristics are taken into account in one of the app by using an intuitively appropriate design, i.e., cartoon type in order to target a young audience. All these considerations about the audience seem sound. However, there is no verification, as the risk communication agencies, other than the SLF, do not have data on who the actual users of the smartphone apps are.

The pyramidal approach as well as the use of some icons is recommended by the European Avalanche Warning Services (EAWS, 2009). None of the interviewees stated that they created their apps according to this specific advice except for the SLF, which acknowledged it in a publication (Winkler & Techel, 2014). Therefore, the detailed process of how the avalanche risk communication community reached the agreement of using the tiered approach for their avalanche bulletins is not known in detail.

3.6.6 Evaluation Types

Evaluations of the apps that were performed fall in the three goal-related types of evaluation of the effectiveness of risk communication described by Rohrmann (1998): content, process and outcome.

The degree of information distribution is (will be) partially performed by all developers. Monitoring the usage of their apps falls within the outcome type of evaluation. Conducting this is an obvious precondition as the apps can in fact only be effective if they are used. However, although the usage is monitored, the characteristics of the users are basically unknown. Therefore, no validation of the choice of target audience and display approach is available to the communicators. The need to obtain information on the users, essential for effective risk communication, is shared by the interviewees. In addition, they are very conscious that deeper outcome evaluations are needed to assess the effectiveness of smartphone apps in terms of understanding change in risk perception and behavior. The fact that it is not done appears to be due to a lack of resources and expertise and not to a lack of interest or willingness.

However, other types of evaluation of the apps are performed. First, the evaluation of the comprehensibility of the icons (app 1) and message (app 4), which is essential for effective risk communication, relates to a content evaluation. These evaluations were useful as they confirmed the adequate use of icons in the first case and resulted in an effective modification of how the message is displayed in the second case. This type of evaluation is the most cited by the interviewees when asked what evaluation are needed or will be implemented. This shows that the communicators acknowledge that efforts are needed to make the representation of the information understandable, as suggested by Burkelijca (2013). Second, requests for feedback are implemented. Those relate to a process evaluation. Although not conducted directly in the concerned app but in a linked website, satisfaction with the bulletin is monitored using a like/dislike button. It might be useful to allow this feedback directly in the apps in order to increase the amount of data collected for this evaluation criterion.

Another kind of process evaluation is the (future) possibility for users to send observations of the current situation to the providers via the apps. Therefore, there is an exchange of information between the risk communication agencies and the information receiver. The potential of this feedback is important. It goes towards citizen science, volunteered geographic information or community-based monitoring (e.g., Buytaert et al., 2014; Haklay, 2013; Stone et al., 2014), approaches that are increasingly used for disaster risk reduction (Maskey, 2011). In the context of important local heterogeneity of the processes, or in case of data scarcity (Storm, 2012), the collection of observation by the users can help to improve the forecast. Moreover, observations and incidents' feedback bring a social media component to the smartphone apps where users can exchange information not only with warning services but also among themselves. If these feedback features develop further, moderation will be needed by the warning services in order to avoid the dissemination of erroneous information. Moreover, it will require to decide whether feedback becomes a real dialogue-oriented two-way risk communication practice, which has been proven to be effective in terms of awareness raising and willingness to learn risk mitigation (Kuhlicke et al., 2011).

3.7 CONCLUDING REMARKS

Based on semi-structured interviews with developers of smartphone applications disseminating avalanche information for risk prevention, this work analyzed the context, the reasons and the ways the apps were developed. Moreover, we investigated how those developers evaluate their products in terms of effectiveness. We were able to highlight how choices were made and what are the remaining challenges that avalanche risk communication faces. Two main results came forward. First, it appears that the debate is currently focusing on the way information is presented rather than on what is the most important content, a debate that seems to be over. Second, the effectiveness of the apps, including the choices of information display, is unknown and urgently need to be evaluated.

The avalanche experts' community is a tight one. This was shown by several observations. The way a snowball effect facilitated the access to the interviewees is a clear example of this. Moreover, it was mentioned, most of the time implicitly but explicitly as well in some cases, that each app developer knows about the other apps, gets inspiration and adopts perceived good practices from each other. This is not only true for the development of the apps. There were long debates among the avalanche forecasters on the ways to disseminate danger information. A result of these discussions was the development of the standard avalanche scale. The fact that this tool is used in all apps shows that avalanche risk communication has reached a high level of uniformity and a consistency that is beneficial to users that are traveling worldwide to enjoy mountaineering. This uniformity is also seen in the fact that the content is presented using a tiered approach and that information helping for decision-making and thus risk mitigation is existent in the apps. However, the specific ways this type of information is presented is not standard. Therefore, the developers are facing an exploration phase in terms of how to display, visualize and explain the message that they want to bring to their users.

The need to evaluate the quality and the effectiveness of the apps is widely acknowledged. Efforts in this sense have been made and further evaluation processes are envisaged. However, several issues are hindering them. Practically, lack of resources and expertise prevents evaluation. Moreover, there is a need to define more precisely the purposes of the apps. The effectiveness of a communication tool should mainly be assessed by an output evaluation that can only be performed if the goal is specified accurately. Many valid purposes are attributed to the apps, from raising awareness to help for decision-making and planning. Ultimately, it is legitimate to ask whether these smartphone applications contribute to the change in behavior and therefore to a reduction of losses, which is the ultimate goal of any prevention campaign. A sound, scientific, assessment is demanding as it requires longitudinal studies that are complex to operationalize. Note that information is not the sole contributing to decision-making (McCammon, 2004b) and as such could be considered of limited use. However, not enough knowledge is currently available to confirm or deny this position. Therefore, risk communicators should pursue their intention to assess whether the message they disseminate with the apps is appropriate, understandable and useful. This need for further evaluations can and should be supported by the contribution of experts in risk communication as well as researchers. Moreover, the impacts of technical issues such as network coverage, on/offline mode, extreme weather conditions and usability on the use of those smartphone applications directly in the field should be addressed to complete an exhaustive evaluation of their effectiveness.

No matter how, the potential of those smartphone applications is important. In particular, in relation to the tendency of these tools to be medium for a two-way risk communication process. The planned upgrade to develop further the possibility for users to report observations and incidents opens the door to adapt these applications for community-based monitoring that can help forecasters or/and sharing information platforms between users.

This study presented the way risk communication tools for avalanche prevention was developed, evaluated and modified. The wealth of expertise and experience available in snow avalanche risk communication should be analyzed and used to build and improve risk communication tools related to other types of natural hazards. An increasing number of disaster risk reduction agencies are developing smartphone apps that are dedicated to informing about danger such as the Disaster Alert App of the Pacific Disaster Center, the Hurricane Flood or Earthquake by American Red Cross Apps or the Wetter-Alarm developed by the Swiss public and private insurance companies. However, there is an evident need to evaluate such products in order to ensure their effectiveness in terms of damage reduction.

3.8 REFERENCES

Atkins, R. (2004) An avalanche characterization checklist for backcountry travel decisions, in: Proceedings of the International Snow Science Workshop, Jackson Hole, Wyoming, USA, 1–10.

Burkeljca, J. (2013). Shifting audience and the visual language of avalanche risk communication, in: Proceedings of the International Snow Science Workshop, Grenoble, France, 415–422.

Buytaert, W., Zulkafli, Z., Grainger, S., Acosta, L., Tilashwork C, A., Bastiaensen, J., De Bievre, B., Bhusal, J., Clark, J., Dewulf, A., Foggin, M., Hannah, D. M., Hergarten, C., Isaeva, A., Karpouzoglou, T., Pandeya, B., Paudel, D., Sharma, K., Steenhuis, T., Tilahun, S., van Hecken, G., and Zhumanova, M. (2014). Citizen science in hydrology and water resources: opportunities for knowledge generation, ecosystem service management, and sustainable development, Front. Earth Sci., 2, 1– 21, doi:10.3389/feart.2014.00026.

Conger, S. (2004). A review of colour cartography in avalanche danger visualization, in: Proceedings of the International Snow Science Workshop, Jackson Hole, Wyoming, USA, 477–482.

Covello, V., Fisher, A., and Bratic Arkin, E. (1991) Evaluation and effective risk communication: introduction, in: Evaluation and Effective Risk Communications Workshop Proceedings, xi-xvii, edited by: Fisher, A., Pavlova, M., and Covello, V., Cincinnati, Ohio, USA.

Dennis, A. and Moore, M. (1996). Evolution of public avalanche information: the North American experience with avalanche danger rating levels, in: Proceedings of the International Snow Science Workshop, Banff, Alberta, Canada, 60–72.

Dransch, D., Rotzoll, H., and Poser, K. (2010). The contribution of maps to the challenges of risk communication to the public, Int. J. Digit. Earth, 3, 292–311, doi:10.1080/17538941003774668.

EAWS. (2009). Reports of Results, 15th European Avalanche Warning Services Conference, Innsbruck, 16–17 June 2009.

Fuchs, S., Spachinger, K., Dorner, W., Rochman, J., and Serrhini, K. (2009). Evaluating cartographic design in flood risk mapping, Env. Hazards, 8, 52–70.

Haklay, M. (2013) Citizen science and volunteered geographic information: overview and typology of participation, in: Crowdsourcing Geographic Knowledge, edited by: Sui, D., Elwood, S., and Goodchild, M., Springer Netherlands, Dordrecht, 105–122.

Harvey, S. and Zweifel, B. (2008). New trends of recreational avalanche accidents in Switzerland, in: Proceedings of the International Snow Science Workshop, Whistler, British Columbia, Canada, 900–906.

Harvey, S., Aegerter, S., and Landolt, D. (2013). White Risk 2.0 – a new web-based platform for avalanche education, in: Proceedings of the International Snow Science Workshop, Grenoble, France, 507–510.

Höppner, C., Buchecker, M., and Bründl, M. (2010) Risk communication and Natural Hazards, in: CapHaz-Net – Social Capacity Building for Natural Hazards – Toward More Resilient Societies, WP5 report, CapHaz-Net Consortium, Birmensdorf, Switzerland, 169 pp.

IDC – International Data Corporation, Smartphone OS Market Share, 2015 Q2, www.idc.com/prodserv/ smartphone-os-market-share.jsp, last access: 19 October 2015.

Jamieson, B. and Stethem, C. (2002) Snow avalanche hazards and management in Canada: challenges and progress, Nat. Hazards, 26, 35–53.

Johnsen, E. (2013). Modern forms of communicating avalanche danger – A Norwegian case, in: Proceedings of the International Snow Science Workshop, Grenoble, France, 7–11.

Klassen, K., Haegeli, P., and Statham, G. (2013). The role of avalanche character in public avalanche safety products, in: Proceedings of the International Snow Science Workshop, Grenoble, France, 493–499.

Kuhlicke, C., Steinführer, A., Begg, C., Bianchizza, C., Bründl, M., Buchecker, M., De Marchi, B., Di Masso Tarditti, M., Höppner, C., Komac, B., Lemkow, L., Luther, J., McCarthy, S., Pellizzoni, L., Renn, O., Scolobig, A., Supramaniam, M., Tapsell, S., Wachinger, G., Walker, G., Whittle, R., Zorn, M., and Faulkner, H. (2011). Perspectives on social capacity building for Natural Hazards: outlining an emerging field of research and practice in Europe, Environ. Sci. Policy, 14, 804–814.

Landrø, M., Kosberg, S., and Müller, K. (2013). Avalanche problems; an important part of the Norwegian forecast, and a useful tool for the users, in: Proceedings of the International Snow Science Workshop, Grenoble, France, 215–218.

Maskrey, A. (2011). Revisiting community-based disaster risk management, Environ. Hazards, 10, 42–52.

McCammon, I. (2004a). Sex, drugs and the white death: lessons for avalanche educators from health and safety campaigns, in: Proceedings of the International Snow Science Workshop, Jackson Hole, Wyoming, USA, 492–501.

McCammon, I. (2004b). Heuristic traps in recreational avalanche accidents: evidence and implications, Aval. News, 68, 42–50.

Meyer, V., Kuhlicke, C., Luther, J., Fuchs, S., Priest, S., Dorner, W., Serrhini, K., Pardoe, J., McCarthy, S., Seidel, J., Palka, G., Unnerstall, H., Viavattene, C., and Scheuer, S. (2012). Recommendations for the user-specific enhancement of flood maps, Nat. Hazards Earth Syst. Sci., 12, 1701–1716, doi:10.5194/nhess-12- 1701-2012.

Rohrmann, B. (1998). Assessing hazard information/communication programs. Australian Psychologist, 33(2), 105-112.

Statham, G., Haegeli, P., Birkeland, K.W., Greene, E., Israelson, C., Tremper, B., Stethem, C., McMahon, B., White, B., and Kelly, J. (2010). The North American public avalanche danger scale, in: Proceedings of the International Snow Science Workshop, Squaw Valley, California, USA, 117–123.

Stone, J., Barclay, J., Simmons, P., Cole, P. D., Loughlin, S. C., Ramón, P., and Mothes, P. (2014). Risk reduction through community based monitoring: the vigías of Tungurahua, Ecuador, J. Appl. Volcanol., 3, 1–14.

Storm, I. (2012). Public avalanche forecast challenges: Canada's large data-sparse regions, in: Proceedings of the International Snow Science Workshop, Anchorage, Alaska, USA, 908–912.

Tase, J. E. (2004). Influences on backcountry recreationists' risk of exposure to snow avalanche hazards, Unpublished Master of Arts, University of Montana, Montana.

Tremper, B. (2006). Avalanche Advisories in the new media age, The Avalanche Review, 24, 9–14.

Tremper, B. and Conway, J. (2006). Graphic avalanche information for the new media, in: Proceedings of the International Snow Science Workshop, Telluride, Colorado, USA, 505–509.

Valt, M. and Berbenni, F. (2013). Avalanche danger variability in level 2 – moderate and – considerable of the European danger scale following the EAWS bavarian matrix: experimental use of icons representing different weight within one degree and scenarios frequency in the last few winter seasons, in: Proceedings of the International Snow Science Workshop, Grenoble, France, 203–208.

Winkler, K. and Techel, F. (2014). Users' rating of the Swiss avalanche forecast, in: Proceedings of the International Snow Science Workshop, Banff, Alberta, Canada, 437–444.

4. An action-oriented research approach to design risk communication effectiveness research

This chapter is based on the following conference paper: Charrière, M., Junier, S.J., Bogaard, T.A., Mostert, E., & Malet, J.-P. 2014. Testing the effectiveness of visual risk communication in reality. A research approach that is beneficial for both scientists and communities at risk. International Conference Analysis and Management of Changing Risks for Natural Hazards, 18-19 November 2014, Padova, Italy.

4.1 BACKGROUND

The objective of this chapter is to show how action-oriented research was used for developing a real-life risk communication effort in the Ubaye Valley in France in order to provide guidelines for meaningful risk communication. The Ubaye Valley is an alpine valley situated in the south-eastern part of France which is affected by numerous natural hazards: landslides, floods and debris flows, avalanches and earthquakes. In terms of demographics, it corresponds to the arrondissement of Barcelonnette which is constituted of 14 communes (Barcelonnette, Ubaye-Serre-Ponçon, La Condamine-Châtelard, Enchastrayes, Faucon-de-Barcelonnette, Jausiers, Le Lauzet-Ubaye, Val d'Oronaye, Pontis, Méolans-Revel, Saint-Paul-sur-Ubaye, Saint-Pons, Les Thuiles and Uvernet-Fours). In total, the arrondissement was populated by 8044 inhabitants in 2013 (INSEE, 2016). According to the communal density grip provided by the INSEE (2017), the communes are sparsely or very sparsely inhabited.

Action-oriented research aims at both increasing scientific knowledge and triggering some kind of social change by involving practitioners, communities or both (Checkland & Holwell, 1998; Small & Uttal, 2005). It is strongly promoted by research funding mechanisms (Small & Uttal, 2005; Mostert & Raadgever, 2008; EU Regulation No 1291/2013). Community-based participatory techniques that aim at the "empowerment of beneficiaries" (Dovie, 2003 in Mercer et al., 2008, p.174) are one type of action-oriented research. They are increasingly used in disaster reduction research (e.g. Le De et al., 2015; Crabtree & Braun, 2015). The importance of collaboration between researchers and other stakeholders is also acknowledged in the context of disaster risk reduction. The Sendai Framework for Disaster Risk Reduction 2015 (UNISDR, 2015), which incorporates the lessons from the implementation of the Hyogo Framework for Action 2005-2015 (UNISDR, 2005), calls for partnerships of researchers and other stakeholders and for strategies that are people-centered and empower local communities.

Previous research in the Ubaye valley (Southern French Alps) has shown that the population requested to be more informed on the topic of natural hazards (Angignard, 2011). Moreover, it has highlighted that scientists were considered a trusted source of information on natural hazards. Both these facts create favourable conditions to conduct an action-oriented research on risk communication, more specifically on raising awareness.

Although effectiveness' assessment should be part of any communication effort (Austin & Pinkleton, 2015, p.72), it is particularly important in risk communication as human lives and properties are at stake. Assessing the effectiveness of risk communication efforts can reveal what works and what does not, which will be very valuable for future communication efforts (e.g. Penning-Rowsell & Handmer, 1990; Covello et al., 1991; Rohrmann, 1992, 1998; McCallum, 1995; Lipkus & Hollands, 1999; Lundgren & McMakin, 2004).

There has been little research on the impact of risk communication efforts related to natural hazards on risk awareness (Charrière et al., 2017 - Chapter 5). Most of the academic evaluations of risk communication concerned a single hazard (e.g. Terpstra et al. 2009; Maidl & Buchecker, 2015). Risk communication, and in particular visual risk communication, has been in the past evaluated primarily in terms of user's requirements, ability to understand the content, and satisfaction (Charrière et al. 2012 - Chapter 2). Moreover, most evaluations were conducted in a laboratory setting (e.g. Spachinger et al. 2008). Laboratory research can be a good way to study the effect of varying individual variables and allows the replicability of studies, but it is disconnected from the real world as it focusses on only a few of the parameters that are involved in a real-world communication process (Checkland & Holwell, 1998; McKay & Marshall, 2001).

In action-oriented research approach the research process is as important as the results and hence it is important to describe it in some detail (Small & Uttal, 2005). This also helps to make the process “recoverable” by research's outsiders (Checkland & Holwell, 1998). In this chapter the stakeholders' engagement process is presented and analyzed in terms of the practical action-oriented research strategies outlined by Small & Uttal (2005). These strategies cover all steps of designing and carrying out a research project with practitioners and community partners, from establishing the partnership to communicating and dissemination findings for further action (Table 4.1).

A chronological approach is thus used here to convey how stakeholders were involved in the development of a risk communication effort (section 4.2), its organization (section 4.3), its testing in terms of effectiveness (section 4.4) and the dissemination of the related scientific results (section 4.5). Section 4.6 analyses this process as an example of action-oriented research approach and section 4.7 presents the concluding remarks.

Action-oriented research steps	Practical strategies
Establishing the partnership	Find a community partner eager to **collaborate** whose interests are compatible with those of the researchers.
	Both parties should state their **needs and constraints**.
	Collaborating towards the identification of **relevant stakeholders**.
Determining the research questions	Focus on research questions that will both help to **create new knowledge** and call for **social change**.
	Be prepared to **modify** the research questions and the research design to comply with unexpected difficulties, new information, changing requirements, etc.
	Explain the research approach to prevent rejection.
	Choose methods that will not be affected by changes in the **sample size**.
	Exploit of **all types of data**, even incomplete data.
Balancing authority and expertise	Choose the **type of authority relationship** that rules the partnership according to the goal of the research and the needs of all stakeholders.
	Anticipate **conflicts** and ways of dealing with them.
Developing the research design and selecting appropriate methods	Balance the **potential tension** between scientific rigor and social relevance; and between depth and breadth of the research.
	Ensure that the **methods fit the context** in terms of complexity and intrusiveness
	Consider **time schedules of the stakeholders** when choosing the methods.
	Target **research goals that are feasible** with the available resources.
Collecting and analyzing data	**Involve community partners** and stakeholders in this phase of the research to empower them, achieve higher quality data, and/or produce a more meaningful analysis.
Communicating and dissemination findings for action	Before concentrating on academic goals, **communicate the results to the community** according to their needs.
	Use style, format, tools and **language suitable** to the target audience.
	Select and prioritize content. Results' meaning and implications for practice should emphasized.

Table 4.1: Action-oriented research steps and strategies. Derived from Small & Uttal (2005)

4.2 DEVELOPING THE EXHIBITION

4.2.1 Access to Stakeholders

In France, at the local level, risk management is the responsibility is shared between (1) the mayor and his/her adjoints who are in charge of the security on the municipality's territory; (2) the Prefect, i.e. the regional representative of the French National State, who takes over when an event affects more than one municipality. In the Ubaye valley, this authority is exercised by the Sub-Prefect; and (3) the technicians from the local branch of the organization Restauration des Terrains en Montagnes (RTM) who are responsible for the management of the hydraulic structures present in torrential basins, the monitoring and the recording of all natural phenomena, the support of competent authorities with respect to natural hazards in spatial planning, and emergency management and mitigation measures' planning (ONF, 2016).

The contact with RTM technicians was made at the very beginning of the project through the help of senior geoscientists from the University of Strasbourg and the TUDelft. Having worked in the area for more than 17 years, they have developed a durable collaboration with the RTM and with the local authorities. The RTM technicians were instantly inclined to collaborate. Throughout the whole development of the communication effort, they assisted in many ways.

Introduction and access to other stakeholders developed according to a snowball process: a stakeholder facilitated the access to other ones, and so on. This approach proved very successful in our work in the small community of the Ubaye valley. For example, we met the employees of the Municipal Library, one of the major group of stakeholders we collaborated with, due to the intervention of two deputy mayors of the municipality of Barcelonnette (Education and Culture). Another example of this snowball process is the way the RTM technicians helped to contact the inhabitants that were video-interviewed for the exhibition.

4.2.2 Development of the Risk Communication Effort

Consultation of and collaboration with the stakeholders enabled the development of a risk communication effort that could be investigating as to its effectiveness: The ‘Alerte’ exhibition. The ‘Alerte’ exhibition was developed in four steps: determining the local state of risk communication and the research opportunities; defining the target audience of the project; determining the specific risk communication effort; and establishing its message (Figure 4.1). Table 4.2 provides a description of the consultation meetings that contributed to these steps.

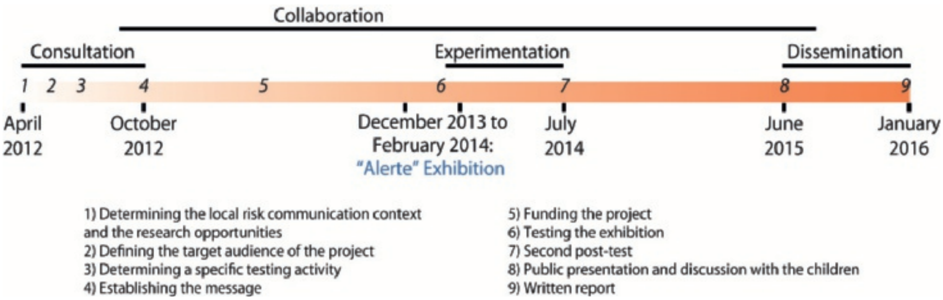


Figure 4.1: Timeline of the development of the 'Alerte' exhibition as well as the evaluation of its effectiveness and the dissemination of the results.

Meeting dates	Stakeholders met	Main findings/activities
April 2012	Local and departmental **technical services** (RTM)	• Past communication efforts targeting the population were presented. In the opinion of the present stakeholders, they were not enough. • The results of previous research on communication had not been disseminated fully.
	Ubaye valley's **inter-municipal body**, one **mayor** of a commune in the Ubaye valley and **members of the local technical service**.	• One target group of the future communication effort could be the elderly persons living in the Ubaye valley for more than 30 years. • Public meetings usually do not work well because people are not motivated to attend. • Local newspapers could be a good medium. • Smartphone app showing real time data on flood would be useful. • Early-warning system would be useful.
	Another **mayor**	• Earthquake hazard should be included in any communication to the population even if the CHANGES project does not focus on it.
	Sous-préfecture (Departmental authority)	• One target group of the future communication effort could be the tourists.
	Fire brigade	• Highlighted the lack of risk communication by the municipalities even though prescribed by law.
July 2012	Initial contact for the dissemination of the **risk managers' questionnaire**	• Realization of the differences between stakeholders in terms of making contact with them and their willingness to participate in a study.
	Risk managers, mayors of the Ubaye valley, departmental authorities, Ubaye valley's inter-municipal body, fire brigade, general public (flyer at its disposal at the Municipal Library)	• Dissemination of the research findings related to communication from the previous research project.
	Visits to eight **tourism professionals**	• The tourism professionals did not seem to be willing to support a communication effort related to natural hazards.
	Deputy of Barcelonnette **municipality** in charge of education, "mobile" departmental school teacher[1]	• Involving the school children in a communication effort related to natural hazards is very important and support from these stakeholders will be given in this regard.
	Employees of the **Municipal Library** of Barcelonnette	• They showed their interest to hold an exhibition on the topic of natural hazard in the library.
October 2012	Employees of the **Municipal Library** of Barcelonnette	• Organization and planning of the exhibition
	"Mobile" departmental school **teacher**	• Organization of the involvement of the children in the research activity
	Local technical services	• Inventory of existing material that could be used in the exhibition

Table 4.2: Details of the consultation meetings with the local stakeholders of the Ubaye valley regarding the development of a risk communication effort.

[1] "Mobile" refers here to the status of the concerned teacher. He is part of the EMALA 04 (Equipe Mobile Académique de Liaison et d'Animation des Alpes de Haute Provence). This organization is a body of itinerant teachers that go to each class every year.

4.2.2.1 Determining the local risk communication context and the research opportunities

One of the main principles of risk communication is that effective efforts are those that take into account the needs of the target audience (Lungren & McMakin 2004). The consultation meetings as well as previous research (Angignard, 2011) showed that targeting the population of the Ubaye valley with a communication campaign was welcomed. In addition, the population survey performed by Angignard is informative in terms of those needs. However, this survey did not focus on visual communication, which was the topic of this research. It was decided to survey local risk managers to get more insights on this. Risk managers were defined as any local stakeholder that plays a role in the risk management cycle, i.e. mayors of the Ubaye valley, sous-préfecture, Inter-municipal body, RTM technicians, municipal technical services, police forces and fire fighters. Because of their tasks, they are in direct contact with the public during several phases of the risk management cycle (prevention, preparedness, response and recovery) and thus it was assumed that they have practical experience with the awareness and preparedness of the population. Moreover, directly surveying the population would have been highly time consuming and complex due to the large variety of individuals that compose the general public.

A questionnaire with close-ended questions was distributed both through an internet survey and hard copies to local risk managers of the Ubaye valley in order to get a clearer picture of the risk communication context in the Ubaye valley (Annex A2, presented in English in this thesis but distributed in the mother tongue of the stakeholders, i.e. French). The questionnaire aimed at (1) gathering the opinions of local risk managers on the awareness and preparedness of the population, (2) collecting information on previous and current communication practices in terms of content, audience and tools, and (3) determining what, in the opinion of local risk managers, were the priorities for future communication in terms of phase of risk management cycle, content and tools. The questionnaire was disseminated to 18 offices of risk managers. Four tourism offices also received the questionnaire as the possibility to include tourists in the study was still investigated.

Sixteen risk managers filled in the questionnaire. The following list summarizes their answers:

- A priori, the older members of the population are, the more they have experienced natural hazards and higher is their awareness and preparedness.
- Past communication efforts conveyed a wide range of information concerning all phases of the risk management cycle on causes of risk, potential consequences of a future event, individual preventive measures, actions taken by the authorities to minimize risk, risk zoning and land use legislation, evacuation plan and emergency procedures, and technical/scientific research outputs. It was, however, argued that the population should be further informed on all these topics.
- Media and public presentations were the most often used tools to inform the population on topics related to natural hazards. The most effective tool used was believed to be the newspapers. Interestingly, it seems that these tools were not perceived to be effective enough as pictures, movies, interactive tools and websites were considered to be more appropriate tools to inform the population.

4.2.2.2 Defining the target audience of the project

The consultation of stakeholders allowed the segmentation of the audience, i.e. the identification and prioritization (Austin & Pinkleton, 2015, p.57) of the sub-groups of the population that the initiative would focus on. Elderly inhabitants, children and tourists were proposed by different stakeholders (Table 4.2). As elderly people and children can be more vulnerable to natural disasters than other age groups (Cutter et al. 2003), we focus on them here. Moreover, risk managers assumed that elderly people have more experience with natural hazards in the Ubaye Valley than other sub-groups (younger adults, children) as they have lived there for a longer time. Consequently, it can be expected that communicating about natural hazards with them might have a lower impact on their awareness than with other sub-groups. Including the elderly people can help to understand the relation between age and natural hazard awareness although this might be variable, as highlighted in the case of flood risk perception (Kellens et al., 2013).
Children are generally seen as a good group to target in order to spread out information to other groups of the population (Finnis et al., 2004; Pangiamore et

al., 2015). From a practical point of view, children were an ideal group to include here because of the great interest of the educational stakeholders in the project. Moreover, children are gathered in one structure, the school, that is easy to approach.

The potential to include tourists in the research activity was highlighted during a discussion (April 2012) with the local representative of the French National State authority. For this person, tourists constitute a priority group to inform about natural hazards as it is likely that they may have no or limited knowledge of the area, the hazards and the action to take. Therefore, two tourism information centers, two hotels, two campings and two providers of outdoor activities were visited. Generally, it appeared from the discussions that these stakeholders were not particularly willing to collaborate. The consulted owners of hotels, campings and providers of outdoor activities did not see the need of informing their clients about natural hazards. The given reason was a fear of frightening people and losing customers. Because of the limited willingness to collaborate, the focus on tourists was not pursued.

4.2.2.3 Determining a specific testing activity

During a formal meeting (July 2012) organized on the advice of the deputy mayor in charge of culture, the Head of the local library suggested holding an exhibition on natural hazards. The only conditions were that, to fit the policies of the venue, the exhibition should address adults and children and that it should be held during the winter 2014-2015. We pursued this idea because the employees of the library understood that the exhibition had to serve research purposes as well and they offered support in many aspects (funding, organization, access to participants). Furthermore, an exhibition is a real communication practice targeting the population and allowing to embrace the topic of natural hazards and associated risks from all the possible perspectives (natural phenomena and mitigation measures). Finally, an exhibition meets some of the criteria (i.e. credibility, reach, flexibility and control) for effective communication formats (Austin & Pinkleton, 2015, p.60) and is highly recommended at villages level, especially if local stakeholders are involved (Firus et al., 2011, p.27). An exhibition presented by scientists and local stakeholders seemed credible in view of the results of the previous population survey (Angignard, 2011): the participants had expressed a great trust in the information provided by those sources. By being free of charge and held in one of the public spaces of the town, the access and context were believed to facilitate reaching the targeted audience. Finally, an exhibition also allows the use of a large variety of tools and visuals that could be tested in terms of effectiveness. Moreover, the extent and the distribution of the messages that they carry is controlled in the setting of an exhibition.

4.2.2.4 Establishing the message

The consultation and collaboration process had as much influence on the message that the exhibition would convey as the literature review. Stakeholders wanted the exhibition to focus on hazards that occur frequently in the Ubaye valley, i.e. earthquakes and snow avalanches, in addition to landslides, debris flows and floods. Moreover, the exhibition should cover as many aspects of natural hazards and associated risks as possible to fit the information needs expressed by the Ubaye population (Angignard, 2011) and the opinion of local risk managers. It was therefore developed around two general aspects of the risk issue: the physical phenomena and the mitigation measures. As the message of risk communication should be tailored to the local situation (Höppner et al. 2010), the topics and sub-topics of the exhibition should be illustrated by local examples. Eventually, all material represented the local context, except for one picture of an avalanche from Norway and videos of earthquakes from Japan. Visual tools (pictures, drawings, graphs, videos, objects) were prioritized to accommodate the research objective, and text was only used to support the pictures. More complex information was presented on supporting information boards to address more comprehensively the topics and to satisfy more expert visitors.

Scientists familiar with the case study and most importantly local stakeholders, in particular RTM technicians, provided the large majority of information and data presented. Inhabitants also contributed by providing pictures and more significantly by agreeing to be interviewed on their personal experiences with natural hazards.

Finally, the reading level of the exhibition was chosen to accommodate the condition given by the multimedia library: the exhibition should ideally target all age groups. Therefore, a reading level suitable for 15 years old teenagers was adopted, assuming that younger children would not have too much interest in the textual parts of the exhibition.

4.2.2.5 Funding the project

An exhibition, even a small one, is costly to design and create. Although staff costs were not taken into account, material costs were important. The research project's funds were not sufficient to cover the expenses. For this matter too, the importance of engaging stakeholders proved to be crucial. The Municipality of Barcelonnette participated, as well as the Seolane centre . Moreover, having presented the project to the Regional Natural Hazards Manager favoured access to regional funds that would be difficult to get for the benefit of such a small community without support.

4.3 THE ‘ALERTE’ EXHIBITION AND SIDE ACTIVITIES

Figure 4.2: Groups of participants to the research activity (adults and children) visiting the “Alerte” exhibition and taking the tests allowing to measure its effectiveness.

The result of the stakeholders’ engagement process was the exhibition “Alerte – ‘ALEas Risques et proTEction’: Connaître les risques en montagne, c’est y être mieux préparé » , which was held for three months during the winter 2014-2015 (Figure 4.2; for the complete description of the exhibition, see Chapter 5 and Annex A3). The exhibition was advertised in several ways with the help of the Municipal Library: in its newsletter, on posters at public advertisement spots in Barcelonnette, in two articles in the local newspapers, and by means of a video reportage on a private regional TV channel.

Several other activities were organized to complement the exhibition. The content of the exhibition was published in a booklet (Charrière et al., 2014). Two public presentations were organized on avalanches. This hazard was chosen as the exhibition was held in winter. The first presentation was given by the ANENA (Association Nationale pour l'Étude de la Neige et des Avalanches, the National Association for the Study of Snow and Avalanches) and was on risk assessment, forecasting and protection measures. The second presentation was from a captain of the Pelotons de Gendarmerie de Haute Montagne (High Mountain Military Police) and dealt with emergency rescue in mountainous areas. Finally, while searching for potential participants in the research activities, contacts were made with the Barcelonnette's hospital. As patients could not be moved, a presentation of the exhibition content was organized at the hospital, followed by a discussion between some school children and the elderly on the experience of the latter with natural hazards. Finally, the content of the exhibition was also presented at a school that was further up the valley and could not bring its pupils to the exhibition due to lack of resources, using slideshows and videos.

4.4 TESTING THE EFFECTIVENESS OF THE EXHIBITION

Approximately 500 persons (n = 494) visited the exhibition (Figure 4.3). Half (n = 253) were "independent visitors", i.e. people that came without being specifically invited. The age classes of the independent visitors, determined by direct observation are the following: children and teenagers (31%), adults < 50 years old (20%), adults >= 50 years old (38%) and adults for which the age could not be estimated accurately (11%). The other half of the visitors to the exhibition (n = 241) were persons invited to participate in the research activities. Thanks to the personal network of the employees of the Municipal Library and their high motivation to assist the research, they promoted the research activity and convinced three groups of elderly people, one group of tourists, one group of employees of the National Park, three groups of teenagers (14 to 18 years old) and 7 classes of children (7 to 11 years old) to visit the exhibition and participate in the full research activity.

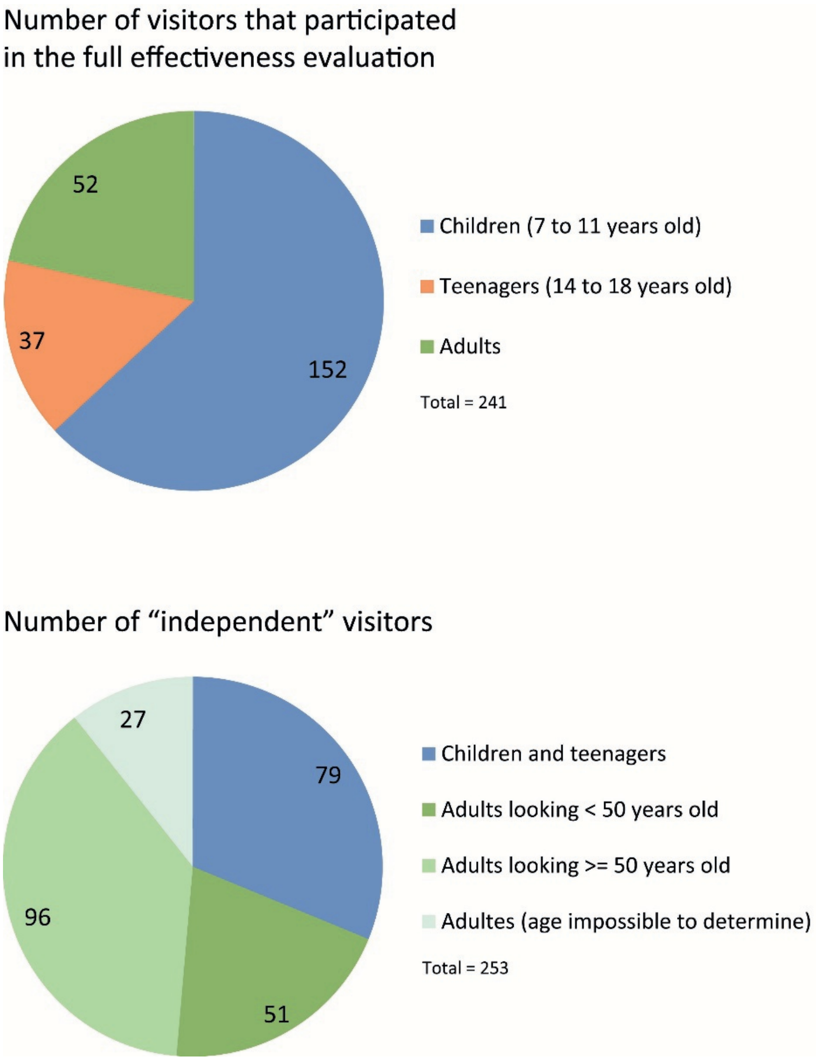


Figure 4.3: Number by age group of the visitors to the 'Alerte' exhibition held at public library of Barcelonnette from December 2013 to February 2014.

The evaluation of the exhibition was conducted using several instruments. A pretest-posttest research design was used to assess the impact of the visit on the risk awareness of the invited participants (see Chapter 5) and their satisfaction with the exhibition (see Chapter 6). The research design was also longitudinal as part of the children participated in a second post-test. Moreover, radio-frequency Identification (RFID) technology was used to monitor how the invited visitors moved in the exhibition in order to evaluate the attractiveness of the different exhibits (see Chapter 6). “Independent” visitors were invited to fill in a satisfaction survey after visiting the exhibition, which was a combination of items of the pre- and the post- tests. Fifty of them (out of 253) completed the survey. Finally, unstandardized observations of the reactions of and interactions between visitors were manually recorded in a notebook when time allowed. The two employees of the Municipal Library were involved in these research design and data collection phases. For example, they helped to tailor the questionnaire to the children (simplification of terms) and assisted in the administration of the survey.

4.5 DISSEMINATING THE RESULTS

The dissemination of the results of the study took place in two phases. In the first phase in June 2015, approximately one year after the last testing phase, the two schools involved were visited and one public presentation was made at the public library of Barcelonnette.

During the school visits the key results were presented to the children and discussed in two one-hour meetings involving most of the children that had participated to the evaluation of the exhibition’s effectiveness. The major point the children made was that they felt more worried about floods after visiting the exhibition as they had become more aware of the potential consequences. Moreover, they disagreed with the conclusion of the survey which indicated that their awareness of natural hazards had not increased a lot due to the exhibition. The discussion with the children suggested that their awareness had truly increased. They were able to describe the natural hazards much better than before their visit to the exhibition. Additionally, they remembered most of the exhibits they had seen, in particular the interactive ones: the flood scale model, the seismograph and the videos. This discussion with the children confirmed the results of the survey in terms of satisfaction with the exhibition as they requested another exhibition. When asked what they would like to see if another exhibition was organized, they expressed the wish for scale models of other hazards than floods, the topic of forest fires and examples of events that took place in other parts of the world. The children were also very keen to talk about their personal experience during the earthquake that had taken place a few months before and to show their awareness of the big earthquake that had just happen in Nepal.

During this discussion, we also learned that some school teachers had further addressed the topic of earthquake hazard. Some teachers had also organized a meeting with one of the inhabitants that had provided a testimony for the exhibition so that the children could learn more about a particular flood event. Additionally, during a school hike near a torrent, one class met a RTM technician by chance. The teacher had asked him to provide an explanation of debris flows. As the experience was highly appreciated, they had planned to organize field trips on natural hazards in the future.

In addition to the school visits, a public presentation of the research activity's results was held in June 2015 at the public library. It was advertised by emails sent to all relevant stakeholders, as well as by the public library newsletter and on boards at the public library. While the dissemination with the children was a real success, the public presentation was less fruitful: only a dozen of people showed up and most of them were the stakeholders involved in the project. The exchange was relatively poor with only a few discussion points raised by the participants on the need for repeated communication efforts to maintain the awareness and for focusing further risk communication efforts on preparedness. Nevertheless, many of the people that were invited (participants in the research activities, authorities and other stakeholders) to the public presentation, and that could not come, excused themselves and confirmed their willingness to receive a written report as proposed in the invitation.

Delivering this written report (Annex A4) was the second dissemination phase. At the beginning of 2016 a four-pages report booklet summarizing the main results of the research was sent to all the people and stakeholders that were involved in the project (n = 79). The four-pages length of the report was decided upon following the advice of local authorities that a longer document would not be read.

4.6 ANALYSIS

In this section the design and testing of the exhibition as well as the dissemination of the results is analyzed, using the action-oriented research steps and corresponding practical strategies proposed by Small & Uttal (2005).

4.6.1 Establishing the Partnership: Finding Collaborators and Identifying Stakeholders

Our work is strictly speaking not fully participative, as the final beneficiaries of the communication effort, the population of the Ubaye valley (the "affected stakeholder": Mostert & Raadgever, 2008), was mostly not involved in the research design. We presented a case of participative research design engaging "influential stakeholders" (i.e. RTM technicians, local authorities and cultural actors) through various degrees of collaboration at different stages of the project (Mercer et al., 2008; Le De et al., 2015). Although not empirically confirmed, the long involvement of scientists in the case study prior to this particular research project, as well as the existence of the Seolane centre, favoured the collaboration with local stakeholders. We can assume that the context of a small community where 'everybody knows each other' is an ideal setting for the identification of relevant stakeholders through a snowball process.

One key aspect of this stage of action-oriented research was an exhaustive needs' assessment through literature reviews and stakeholders' meetings and by complying with the schedule and double target audience constraint imposed by the Municipal Library. On the other side, all stakeholders understood that the project had a scientific goal. Publications of results as well as other PhD requirements were communicated at an early stage and accepted by the stakeholders.

At this stage, we were confronted with conflicts of opinions between some stakeholders. While the tourists were mentioned as an important sub-group of the population to focus on, the tourism professionals did not seem to agree. As collaboration seemed the most important factor for the success of the research activity, the focus on tourists was dropped. Considering the importance of collaboration in the process of designing and testing the exhibition, it is still believed that this was a good choice to make. However, focusing on tourists is still socially and scientifically relevant. For future research two options could be considered. First, negotiations with the tourism professionals. Maybe the leverage of local authorities can help to convince them of the need to inform tourists on natural hazards and the importance of collaboration to achieve this. If this is not possible, tourists could be targeted without the help of the tourism professionals but with the help of other stakeholders.

4.6.2 Determining the Research Questions and Measures

Involving stakeholders from the start of the research means that modifications of the initial research plan may be necessary. In the Ubaye case, the communication effort was originally planned to focus on hydro-meteorological hazards only. However, several stakeholders remarked that earthquakes and avalanches needed to be included as well. Therefore, the communication effort to be tested became a truly multi-hazards one.

More importantly, following one stakeholder's idea of organizing an exhibition had a great impact on the research questions. The exhibition consisted of seven types of media and tools conveying various messages related to the physical phenomena and mitigation measures. Thus, the effect on awareness that could be measured was the effect of the exhibition as a whole had and not of specific exhibits. However, the satisfaction survey and the Radio-frequency identification (RFID) measurements were used to partially overcome this drawback and provide some insight in which tools were most attractive and potentially had the biggest impact.

Small & Uttal (2005) warn about the difficulties of implementing pre-test/post-test or longitudinal experimental design due to potential changes in the groups with which the scientists work. Population changes between the pre-test and the first post-test were not an issue in this experimental setting as they were taken right before and right after the visit to the exhibition. Although fewer children participated in the second post-test inducing a potential bias in the longitudinal part of the analysis, the results were found to be meaningful and informative.

4.6.3 Balancing Authority and Expertise

In action-oriented research there are several models of partnerships: an egalitarian one, where stakeholders are involved at all stages of the research process; one where the authority and expertise are in the hands of the scientists; and one where the power is given to the stakeholders. The study described here mainly follows the second model. While the stakeholders were extensively involved in the choice, design and testing of the exhibition, they were only partially involved in the analysis of the results, the writing of the results and the formulation of the recommendations.

An unsuitable balance of authority and expertise can result in conflicts that can put a collaborative project in peril. At the beginning of the project, some stakeholders expressed their frustration over the unsuitable and meaningless way results from previous research had been disseminated to them. As those stakeholders were crucial for this project, quite a substantial amount of time was taken by the project's scientists to rewrite and disseminate a concise report of these results in order to restore trust (Annex A5).

Another criterion for a successful collaborative project is the building of a friendly environment. This was achieved by the high commitment of the scientists, especially in terms of time spent in the case study area. Several short visits (4 days to 2 weeks) were made before the opening of the exhibition and a full-time presence was ensured during the 11 weeks of the exhibition. This enabled the creation of friendly relationships that were rewarding. Moreover, it allowed to observe that the project triggered collaborations between the most involved stakeholders. It also appeared that the exhibition was a space for sharing memories, asking questions and discussion. Those observations are not directly useful to answer the research questions, but they show the relevance of the exhibition for the community.

4.6.4 Developing the Research Design and Involving Community Partners in Data Collection and Analysis

Conducting action-oriented research requires resources. It is clear that without the contributions of local stakeholders in terms of funding and time, the creation of the exhibition and the testing would not have been possible. A sample of about 8.6% of the population of Barcelonnette (241 participants for 2084 inhabitants in 2013, INSEE, 2013) participated in the pre/post-tests design. The personal and professional relations of trust that the employees of the Municipal Library have with cultural associations and schools facilitated the access to the participants and the advertisement of the exhibition. However, the fact the Municipal Library is mostly open during working hours led to the lack of working adults in the research. Therefore, communication guidelines for this particular audience are missing from the conclusions of the research. Since the employees of the Municipal Library belong to the community and are usually well-known by the participants, it is

assumed that their presence and encouraging words, especially towards the children, increased the motivation of participants to fill in the long surveys.
In this project, stakeholders were not directly involved in the data analysis. However, they were asked to comment on the results during the dissemination phase. Few people used the opportunity. If such engagement process was to be renewed, attention would have to be paid to setting up, at the start of the project, a favorable environment for the participation of stakeholders in the interpretation of the results.

4.6.5 Communicating and Disseminating Findings for Action

Communicating and disseminating the findings is key for the scientists to be considered as a reliable partner by the stakeholders. In this project, this was clearly shown at the very beginning when some stakeholders complained about the lack of dissemination from a previous project.
The form, style and content of the dissemination material is crucial to make the results understandable and useful. Stakeholders from the Municipal Library were consulted to design the dissemination material for the public conference and the visit to the schools. For the latter, there is no doubt that it was a success considering the extensive exchange that occurred. However, even though previous research had shown that the population would attend public presentations on the topic of natural disasters (Angignard, 2011), very few persons actually attended the one that was organized. Future efforts should consider to advertise such events more intensively or look into other ways to disseminate findings.

Members of local authorities were asked to provide guidelines on the format of the report that was later disseminated to all stakeholders. They were very clear on the fact that is should be short and concise. Special attention was given to this point. We only selected the results that we believed to be useful for the design of future risk communication efforts in the case study. Results concerning how to measure awareness were left out as they are mainly of interest for an academic audience. Considering the high amount of congratulations and acknowledgments statements received in response to the email with the report, we assume that the stakeholders were satisfied. Moreover, people that were not anymore part of the authorities due to the fact that they were not reelected, highly appreciated that they were remembered as being part of it at the time of the exhibition.

Action-oriented research is deployed with the goals changing a social issue. The short-time awareness of the population increased due to the visit of the exhibition (see Chapter 5). However, the longitudinal part of the research was too limited to provide results on the long-term effect of the exhibition. Moreover, it is unknown if the project informed further local risk communication practices. This is a drawback of research carried out in a funding framework based on projects that are limited in time.

4.7 CONCLUDING REMARKS

This chapter presented the stakeholder engagement process that resulted in the design of an exhibition, which was evaluated as to its effect on risk awareness. The stakeholders chose this communication effort themselves and also contributed to the research design, data collection and dissemination.

Even though the stakeholders participated less in the data analysis, this research project can be considered as a successful example of action-oriented research. It addressed an issue that was relevant for the community and could trigger social change. The evaluation of the effectiveness of the exhibition is locally meaningful as it provided guidelines for further communication efforts in the Ubaye valley. The social relevance of the project can also be seen in the reinforcement of the relationships between stakeholders as they met and discussed the design and creation of the exhibition. Moreover, the project triggered memories of past events, especially for the older generations. In addition, it encouraged the exchange between generations, at the exhibition as well as during peripheral activities that resulted from this research. Finally, it promoted further communication efforts: during the exhibition, two conferences related to avalanche risks were proposed to the population; and informal discussions with stakeholders showed that they realized the importance of risk communication.

The project also advanced knowledge of risk communication's impacts as well as of the measurement's operationalization of the complex cognitive construct of risk awareness in a multi-hazards context. In addition, reporting on the stakeholders' engagement process enhanced the transparency of the research and is informative for peer scientists. Indeed, it highlighted the benefits but also the constraints and limits of using an action-oriented approach in risk communication research. By participating in the research, the stakeholders can steer the research in a direction that suits their needs and requirements. For the researcher, collaboration with stakeholders is often necessary for conducting field research instead of a lab research, can help to adapt to the local context, and facilitates the testing and creation of new ideas.

Deploying an action-oriented approach in this case study highlighted some constraints that are imposed on scientists. First, research can go at slower pace than recommended by the academic community. Secondly, collaboration with stakeholders implies that their needs and wishes have to be considered. This may necessitate changes in the initial research plan. While this can be positive (for example, in this work, including all relevant hazards), it can also be problematic. In this project, tourists were a relevant sub-group to focus on both socially and scientifically, but they were not included in the reearch as influential stakeholders were against it. Thus, the scientist may have to compromise and dismiss some research questions, or not compromise and face potential opposition. Finally, generalization of the results of an action-oriented approach is difficult. If the approach of this project were applied in another case study, the communication effort to be tested would most likely be different because the needs of the local community would be different, for example because of different natural hazards, a different risk culture, a different history of risk communication, a different governance system and different social relations. However, action-research does allow to collect real-life data that are needed to complement potential laboratory data. In this way it can advance research on the effectiveness of risk communication.

4.8 REFERENCES

Angignard, M. (2011). Applying risk governance principles to natural hazards and risks in mountains. PhD Dissertation, Dortmund University of Technology. https://d-nb.info/1018126872/34. Last accessed: 7 Mar 2018.

Austin, E. W., & Pinkleton, B. E. (2015). Strategic Public Relations Management: Planning and Managing Effective Communication Campaigns (Vol. 10). Routledge.

Charrière, M.K.M., Junier, S.J., Mostert, E., & Bogaard, T.A. (2012). Flood risk communication – Visualization tools and evaluations of effectiveness. Proceedings of the 2nd European Conference on FLOODrisk Management, November 20-22, 2012, Rotterdam, The Netherlands.

Charrière, M.K.M., Malet, J.-P., Bogaard, T.A., Junier, S.J., Mostert, E., and Remaître, A. (2014). “ALERTE: Connaître les risques en montagne, c’est y être mieux préparé » - Documents pédagogiques présentés lors de l’exposition, Barcelonnette, 19 décembre 2013 - 19 février 2014. Les cahiers de Séolane, 3, Edition Séolane, Barcelonnette. (http://eost.u-strasbg.fr/seolane/presse/images/2014/cahiers_seolane_3.pdf; last accessed 10.09.2017)

Charrière, M.K.M., Junier, S.J., Bogaard, T.A., Mostert, E., Malet, J.-P. & Van de Riesen, N.C. (In Press). The impact of an exhibition on risk awareness of the general public in mountainous areas, International Journal of Disaster Risk Reduction.

Checkland, P., & Holwell, S. (1998). Action research: its nature and validity. Systemic Practice and Action Research, 11(1), 9-21.

Covello, V., Fisher, A., & Bratic Arkin, E. (1991) Evaluation and effective risk communication: introduction, in: Evaluation and Effective Risk Communications Workshop Proceedings, xi-xvii, edited by: Fisher, A., Pavlova, M., and Covello, V., Cincinnati, Ohio, USA.

Crabtree, C., & Braun, K. (2015). PhotoVoice: a community-based participatory approach in developing disaster reduction strategies, Progress in community health partnerships: research, education, and action, 9(1), 31-40.

Cutter, S.L., Boruff, B.J., & Shirley, W.L. (2003). Social vulnerability to environmental hazards, Social science quarterly, 84(2), 242-261.

Dovie, D. B. (2003). Whose involvement? - can hierarchical valuation scheme intercede for participatory methods for evaluating secondary forest resource use?, Forest Policy and Economics, 5(3), 265-283.

European parliament and council (2013). Regulation (EU) No 1291/2013 of the European parliament and of the council of 11 December 2013 establishing Horizon 2020 - the Framework Programme for Research and Innovation (2014-2020) and repealing Decision No 1982/2006/EC.

Finnis, K., Standring, S., Johnston, D & Ronan, K. (2004). Children's understanding of natural hazards in Christchurch, New Zealand, Australian Journal of Emergency Management, 19(2): 11-20.

Firus, K., Fleischhauer, M., Greiving, S., Grifoni, P., & Stickler, T. (2011). Planning and implementing communication and public participation processes in flood risk management, Procedural guidelines and toolbox of methods.

Höppner, C., Buchecker, M. & Bründl, M. (2010). Risk communication and Natural Hazards, CapHaz-Net - Social Capacity Building for Natural Hazards - Toward More Resilient Societies, vol CapHaz-Net WP5 report, Birmensdorf, Switzerland.

INSEE, Institut National de la statistique et des études économiques (2016). Evolution et structure de la population en 2013 – Arrondissement de Barcelonnette (041), https://www.insee.fr/fr/statistiques/2020130?sommaire=2106142&geo=ARR-041, last accessed : 6 Mar 2018.

INSEE, Institut National de la statistique et des études économiques (2017). The communal density grid. https://www.insee.fr/fr/information/2114627, last accessed: 7 Mar 2018.

Kellens, W., Terpstra, T., & De Maeyer, P. (2013). Perception and communication of flood risks: a systematic review of empirical research. Risk Analysis, 33(1), 24-49.

Le De, L., Gaillard, J. C., & Friesen, W. (2015). Academics doing participatory disaster research: how participatory is it? Environmental Hazards, 14(1), 1-15.

Lipkus, I.M. & Hollands, J.G. (1999). The visual Communication of Risk, Journal of the National Cancer Institute Monographs, 25, 149-136.

Lundgren, R. & McMakin, A. (2004). Risk communication - A Handbook for communicating environmental, safety and health risks, Battelle Press, Colombus, USA.

Maidl E. & Buchecker, M. (2015). Raising risk preparedness by flood risk communication. Natural Hazards and Earth System Science, 15(7), 1577-1595.

McCallum, D.B. (1995). Risk Communication: a tool for behaviour change, Reviewing the behavioural science knowledge base on technology transfer, NIDA Research Monograph 155.

McKay, J., & Marshall, P. (2001). The dual imperatives of action research. Information Technology & People, 14(1), 46-59.

Mercer, J., Kelman, I., Lloyd, K., & Suchet-Pearson, S. (2008). Reflections on use of participatory research for disaster risk reduction. Area, 40(2), 172-183.

Mostert, E., & Raadgever, G. T. (2008). Seven rules for researchers to increase their impact on the policy process. Hydrology and Earth System Sciences, 12(4), 1087-1096.

ONF - Office National des Forêts. La responsabilité sociale, pilier de la gestion durable de l'ONF (last accessed on the 16th of June 2016) http://www.onf.fr/onf/sommaire/developpement_durable/responsabilite_sociale/20080707-163358-637238/@@index.html

Piangiamore, G. L., Musacchio, G., & Pino, N. A. (2015). Natural hazards revealed to children: the other side of prevention. Geological Society, London, Special Publications, 419(1), 171-181.

Penning-Rowsell, E., & Handmer, J. (1990). The changing context of risk communication In: Handmer, J., and Penning-Rowsell, E. (eds.) Hazards and the communication of risk. Gower Technical.

Rohrmann, B. (1992). The evaluation of risk communication effectiveness. Acta Psychologica, 8,169-192.

Rohrmann, B. (1998). Assessing hazard information/communication programs. Australian Psychologist, 33(2), 105-112.

Small, S. A. & Uttal, L. (2005). Action-oriented research: Strategies for engaged scholarship. Journal of Marriage and Family, 67(4), 936-948.

Spachinger. K., Dorner, W., Metzka, R., Serrhini, K. & Fuchs, S. (2008). Flood risk and flood hazard maps – Visualization of hydrological risks. In XXIVth Conference of the Danubian Countries. IOP Publishing.

Terpstra T., Lindell, M.K., Gutteling, J.M. (2009). Does Communicating (Flood) Risk Affect (Flood) Risk Perceptions? Results of a Quasi-Experimental Study. Risk Analysis, 29(8), 1141-1155

UNISDR (2005). Hyogo framework for action 2005-2015: building the resilience of nations and communities to disasters. Extract from the final report of the World Conference on Disaster Reduction, A/CONF. 206/6.

UNISDR (2015). Sendai framework for disaster risk reduction 2015–2030. In: UN world conference on disaster risk reduction, 2015 March 14–18, Sendai, Japan. Geneva: United Nations Office for Disaster Risk Reduction.

5. The impact of an exhibition on risk awareness of the general public in mountainous areas

This chapter is published as the following journal paper: Marie K.M. Charrière, Sandra J. Junier, Thom A. Bogaard, Erik Mostert, Jean-Philippe Malet, & Nick C. van de Giesen, The impact of an exhibition on risk awareness of the general public in mountainous areas, International Journal of Disaster Risk Reduction, 25, 36-59, 2017, https://doi.org/10.1016/j.ijdrr.2017.07.011, 2017.

5.1 INTRODUCTION

Mountainous areas are typically affected by multiple natural hazards, such as floods, debris flows, landslides, avalanches and earthquakes that threaten society socially and economically (Zingari & Fiebiger, 2002). Between 1982 and 2005, natural hazards induced economic losses added up to EUR 57 billion in the Alps alone (OECD, 2007). Risk management can help to reduce losses.

Currently, there is a shift in risk management towards integrated approaches that focus on prevention and preparation (Höppner et al., 2012). This brings the importance of risk communication to the fore. The definition of risk communication itself has changed from a process of informing individuals about risks (Plough & Krimsky, 1987) to actions based on dialogue (Leiss, 1996; Höppner et al., 2010). Risk communication favors the expansion of social capacities (Höppner et al., 2012), such as the knowledge, skills and networks that are needed to successfully manage hazard occurrences (Kuhlicke et al., 2010). However, as two-way communication is very demanding to put into practice and communities are not always inclined to participate, risk communication often remains one-directional. Applied research on one-directional risk communication therefore remains important (Maidl & Buchecker, 2015).

One of the goals of risk communication on natural hazards is to raise public awareness of the hazards (Keller et al., 2006). A well-known definition of public awareness is “the extent of common knowledge about disaster risks, the factors that lead to disasters and the actions that can be taken individually and collectively to reduce exposure and vulnerability to hazards” (UNISDR, 2009, 2015). However, awareness is more than factual knowledge. It is a mental construct (Wachinger et al., 2013) that is multi-dimensional and is linked to personal attitudes (Maidl & Buchecker, 2015). Awareness raising efforts have to take the risk perception of the target audiences, i.e. their intuitive risk judgements (Slovic, 1987), into account (Davis et al. 2003). These are linked not only to the perception of the probabilities of occurrence and consequences of an event (Bubeck et al., 2012), but also to emotions (e.g. Loewenstein et al., 2001; Slovic et al., 2007; Miceli et al., 2008). In addition, personal experience with natural hazards and demographic factors such as age, gender and education have been found to play a role (Terpstra et al., 2009; Kellens et al., 2013; Wachinger et al., 2013).

To contribute to risk management, risk communication must of course be effective, i.e. it must fulfill the goal for which it was designed. The effects depend on the source of the message, its content and the attributes of the target audiences (Breakwell, 2000). Demographic characteristics of the public must be taken into account, but also their mental models (Atman et al., 1994), believes, concerns (Frewer, 2004) and values (Burnimgham et al., 2008). Moreover, trust in the communicators (Covello & Sandman, 2001) and the use of suitable formats (Bier, 2001) must be ensured. However, even if those preconditions are met, one cannot take for granted that risk communication is effective without having conducted an evaluation.

In the last decades, the need for evaluating risk communication has been stressed in the literature (e.g. Penning-Rowsell & Handmer 1990; Covello et al., 1991; McCallum, 1995; Lundgren & McMakin, 2004). Rorhmann (1992, 1998), for instance, acknowledged the importance of empirical evaluation in order to assess whether a specific effort was successful or needed to be ameliorated or replaced by something else. He remarked, like others (e.g. Covello et al., 1991; Neresini & Pellegrini, 2008), that effectiveness depends on the goal set for the given communication effort. Several types of evaluations can be performed: content, process, or outcome (i.e. summative) evaluations. One possible outcome or impact of public communication is the change that it produces to those that were involved in it, in terms of knowledge, beliefs, attitudes and behavior (Fishhoff, 2012; Neresini & Pellegrini, 2008).

Evaluations of communication outcomes in relation to natural hazards are not common (Terpstra et al., 2009). Scientific research focusses more on the content evaluation in laboratory research settings (Charrière et al., 2012). In general, practice and research on risk communication concentrates on floods (Charrière et al., 2012; Höppner et al., 2012). This also applies to the few studies focusing on outcome evaluation of risk communication. In his research from the Netherlands, Terpstra et al. (2009) measured only small effects of risk communication through workshops on the flood risk perception, but he also found that a lack of updated and relevant information may reinforce inappropriate beliefs. Concerning Zürich, Maidl & Buchecker (2015) found that a once only dissemination of written information concerning flood risks only slightly increased risk awareness and risk preparedness of their targeted audience.

This observed lack of studies on the effects of risk communication on awareness calls for more research. Therefore, the goal of this study is to measure the effectiveness of an exhibition on risk, the “Alerte” exhibition. This exhibition, held in the Ubaye Valley, a small mountain community in the southern French Alps, aimed at increasing risk awareness of the general public. Different types of audiences were targeted and different hazards were addressed, reflecting the reality in many small mountainous communities, where funds are usually too limited to have separate communication efforts for different audiences and hazards. Moreover, it aimed to measure factors that constitute or influence risk awareness, specifically knowledge, attitudes to risk, previous experience, exposure to awareness raising, ability to mitigate, worry and demographic characteristics. In addition, the goal is to measure the persistence of risk communication on risk awareness of children by using a longitudinal approach with two post-tests separated by several months. Assessing the long-term effects is as necessary for understanding risk awareness as for understanding risk perception (Siegrist, 2013). Most of the published research focusses on the personal characteristics of individuals that play a role in risk awareness in order to provide guidelines for risk communication practices. In our case, we also tested to what extent and how a risk communication effort can change the attitudes and perceptions that constitute risk awareness.

The paper is organized as follows: section 5.2 presents the development and the content of the intervention, i.e. the “Alerte” exhibition, and the methodology used to assess the effectiveness of this intervention. Sections 5.3 and 5.4 present the characteristics of the participants and the observed changes in risk awareness. Section 5.5 discusses these changes. Section 5.6 contains the conclusion.

5.2 INTERVENTION DEVELOPMENT AND METHODOLOGY FOR MEASURING CHANGES IN PUBLIC AWARENESS

5.2.1 The Development of the “Alerte” Exhibition

In order to be able to test the effectiveness of risk communication on public awareness, a real-life communication effort was developed using an action-oriented research approach (Checkland & Holwell, 1998; Small &Uttal, 2005). A two years’ consultation and collaboration process with the local authorities and risk managers of the Ubaye Valley (Southern French Alps) as well as with scientific experts of the area lead to the exhibition “Alerte – ‘ALEas Risques et proTEction’: Connaître les risques en montagne, c’est y être mieux préparé “(English translation: “Alert – ‘Hazards, risks and protection ‘: Knowing the risks in mountains to be better prepared”) at the public multimedia library of Barcelonnette.

The Ubaye Valley is highly exposed to several natural hazards. In the last 100 years, at least 72 earthquakes, 119 landslides, 144 snow avalanches, as well as 414 floods and debris flows were reported (database of local technical risk managers, i.e. Restauration des terrains en montagne – Office National des Forêts). These events frequently caused damage to infrastructure and buildings but did not cause a large number of victims.

Results of a prior survey on hazard information needs in the Ubaye Valley (Anginard, 2011) had shown that the population perceived a broad range of aspects of natural hazards as important topics of information. Because of the expressed needs of the target audience, the exhibition was created around two general topics: the physical phenomena and the risk management. This research had also concluded that the population in the Valley has great trust in the risk information provided by scientists, so this precondition for effective risk communication was met in our case.

The exhibition focused on all natural hazards occurring in the Ubaye Valley, i.e. landslides, debris flows and floods, earthquakes, and snow avalanches. This was requested by local stakeholders, in particular the technical risk managers. Another reason behind this choice was to accommodate scientific perspectives such as multi-hazard risk assessments. This approach has been advocated for mountainous regions to avoid misjudgment of the general risks (Bell & Glade, 2004) and can form the basis for multi-hazard risk management and, consecutively, multi-hazard risk communication.

The topics of the exhibition were all illustrated by local examples, except for one picture and one video. Local authorities, risk managers and cultural partners as well as inhabitants and scientists familiar with the area provided most of the information and data. Visual tools were prioritized to present the information, with only some supporting text (Table 5.1). The reading level of the latter was chosen to be suitable for 10-15 years old children as the Library requested that the exhibition should target both children and adults, and as it was assumed that younger children would not spend much time on reading. More in-depth information was included on A3 posters located next to A0 posters in order to target a potentially more expert audience. The exhibition was held at the Library between 04.12.2013 and 19.02.2014 in two rooms of 80 m2 in total. It could be visited free of charge 18 hours a week.

Exhibits	**Numb**	**Content**	**Visuals**
A0 Posters	15	Concept of risk, avalanches, landslides, torrential floods, debris flows, earthquakes, security guidelines, non-structural mitigation measures, structural mitigation measures, technical agency in charge of risk management.	Pictures, drawings, symbols, graphs, diagrams, color schemes, maps, scales.
Supporting information boards (30*30 cm)	12	Scientific definitions and explanations, additional information.	Pictures, drawings, symbols, maps.
120*400 cm Poster	1	Timeline of all reported events from the 19th century and important regulation changes, highlight of major events.	Pictures, old newspapers, histograms.
Numerical timeline (Ipad)	1	Web-based numerical timeline of all reported events from the 19th century and important regulation changes, highlight of major events.	Pictures, archives.
Flood scale model	1	330x80 cm model of Barcelonnette (DEM based) with manual system to simulate a flood.	-
Seismograph	1	-	Dynamic graph.
Videos (TV)	4	4 videos of local events (triggered avalanche, rockslide and debris flow) and earthquakes effects (Japanese compilation of videos from different countries)	Videos.
Videos (Ipad)	15	Testimonies of witnesses (local inhabitants) of events, technicians and scientists.	Videos.
Emergency kit	1	Emergency kit according to French ministry advices	Objects in showcase.
Google Earth map	1	Local area with descriptive pins at location of major events or important mitigation measures	Pictures, archives.

Table 5.1: Exhibits (content and used visuals) presented at the 'Alerte' exhibition.

5.2.2 Research Instrument, Design and Participants

The impacts of the exhibition were measured using a pre-test/post-test research design with a panel sample using questionnaires, and following the holistic data collection framework proposed by Enders (2001). This framework for measuring emergency awareness and preparedness is based, among others, on Rohrmann's (1998) risk communication model, which stipulates that the output of communication is influenced as much by economic, societal and individual factors as by the concrete communication effort. Enders proposed six factors, as well as questions for each factor, that should be taken into account: hard knowledge, attitudes to risk, previous experiences of emergencies, exposure to awareness raising, ability to mitigate/ prepare/ respond and demographic characteristics. The items of the questionnaires were inspired by the list proposed by Enders (2001) and adapted to our specific case. We added two factors, i.e. the worry level, as there is a consensus in literature that emotions also have an impact on risk perception, and the level of self-reported awareness, as we are aiming at measuring awareness. The questions either used a 5-points Likert scale or were close-ended. The changes, i.e. impacts of the exhibition, were analyzed using four dependent factors, i.e. attitudes to risk, ability to mitigate/prepare/respond, worry level and self-reported awareness. These factors were included in both the pre-test and the post-tests (Table 5.2, questionnaires in Annex A6).

FACTOR	INDICATORS	TESTS
Dependent		
Worry	Worry about floods/landslides/debris flows/earthquakes/snow avalanches	Pre-test Post-tests
Self-reported awareness	Feeling of being aware of natural hazards occurring in the Ubaye valley	Pre-test Post-tests
Ability to mitigate/respond/prepare	Feeling of being vulnerable to natural hazards occurring in the Ubaye valley Feeling of having all the knowledge and information to respond to natural hazards occurring in the Ubaye valley, Feeling of having all the material and financial resources to respond to natural hazards occurring in the Ubaye valley* Feeling of being prepared for natural hazards occurring in the Ubaye valley	Pre-test Post-tests
Attitude to risk	Likelihood of floods/landslides/debris flows/earthquakes/snow avalanches occurring in the next 5 years in the Ubaye valley Consequence of floods/landslides/debris flows/earthquakes/snow avalanches occurring in the Ubaye valley	Pre-test Post-tests
Independent		
Previous experience	Direct experience -> Number of times floods/landslides/debris flows/earthquakes/snow avalanches were experienced -> Impacts on health or belongings Indirect experience: -> Knowledge of persons impacted by natural hazards	Pre-test
Demographics	Age, Gender, last obtained degree, whether work is related to natural hazards	Pre-test
Exposure to awareness raising	Time living in the valley Prior amount of information received on floods/landslides/debris flows/earthquakes/snow avalanches Impact of prior information on awareness* Impact of prior information on the motivation to become prepared*	Pre-test
	Amount of new information on floods/landslides/debris flows/earthquakes/snow avalanches received by visiting the exhibition Impact of the new information on awareness Impact of the new information on the motivation to become prepared	Post-test
	Amount of new information on floods/landslides/debris flows/earthquakes/snow avalanches received between the two post-tests Whether the topic of natural hazards was discussed after the visit of the exhibition with the parents, the friends or at school.	Second post-test
Hard knowledge	9 questions. See Figure A7.6 in the Annex A7	Post-tests

Table 5.2: Factors tested in the pre-test and/or post-tests with indicators' description. Items marked with a * were not asked in the children's questionnaire.

In this paper, the term “awareness” is used to cover the concept defined by all these factors. The questions related to the factors that could not be impacted by the visit to the exhibition, i.e. the independent ones, were asked either in the pre-test or in the post-tests. Changes in hard knowledge were not measured because asking questions on hard knowledge in the pre-test would trigger visitors to look for the answers during their visit to the exhibition and would therefore bias results. Therefore, these questions were asked in the post-tests only.

A total of 52 adults participated in this study after having been invited by the library, who contacted local associations and touristic resorts. Moreover, secondary and primary schools classes were asked though the same channel to join the activity, resulting in 37 teenagers and 152 children participating in the study.

The procedures of taking the test were as follows. All groups took the pre-test immediately before visiting the exhibition (Figure 5.1). The test was first introduced to the groups of adults and teenagers to verify whether they knew the natural hazards addressed by the exhibition and avoid that they did not understand or did not answer the questions. They generally knew the differences between the different hazards and all proceeded to do the tests on their own. If more explanation on the questions was requested, it was given. More extensive explanation was needed for the children. They usually did not know what a debris flow is and mixed up landslides and earthquakes. This is due to similar terms for these two phenomena in French, i.e. respectively “mouvements de terrain” et “tremblements de terre”. For the children, each question of the test was read out loud, one at a time.

Adults and teenagers completed the post-test individually immediately after the visit. Due to time constraints, children took it later on the same day when they were back at the school or the following day. Four to six months later, some of the primary school classes agreed to participate to a second post-test. For all groups, the tests were completed using hard copies.

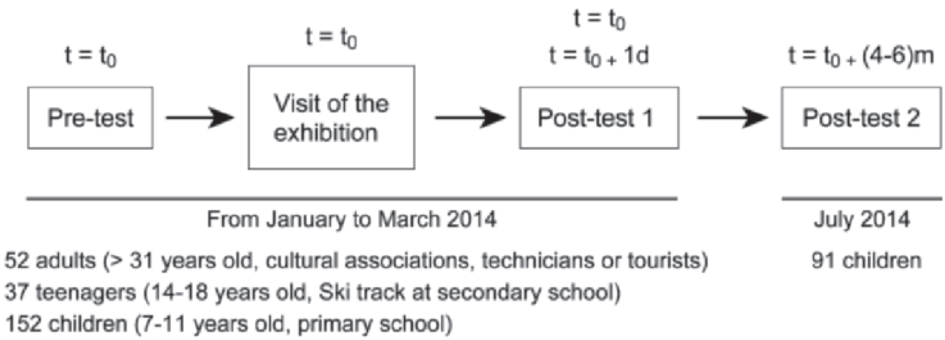


Figure 5.1: Research design. t = time, d = day and m = month.

Following the advice of the Library's employee in charge of children activities, the tests for this group were slightly modified. Questions on material and financial resources (ability to mitigate/prepare/respond) as well as diploma and work (demographics) were removed as they are not applicable to this group. Moreover, questions on the impacts of prior/new information on motivation to become prepared and of prior information on awareness were not asked of the children in order to reduce the length of the questionnaire. Finally, the use of the term "awareness" was replaced by "knowledge" as the first term was believed to be too complex for the children. In the second post-test that the children took, several questions were added. They addressed additional information about natural hazards or discussions that could have taken place in-between the two post-tests. Therefore, potential changes can be analyzed in the light of these facts. The children's parents were informed beforehand that their children would participate in a scientific experiment and that they could oppose to it. None did.

5.2.3 Description of the Statistical Test and Analyses

In social sciences research, Likert scale data are often statistically analyzed as if they are interval scale data, and measures of changes are most often conducted using paired t-tests. Statisticians, however, oppose the use of such tests for Likert scale data (Cohen & Lea, 2004), as Likert scales are in fact ordinal and data is usually not normally distributed (Chao et al., 2010). An alternative non-parametric test, i.e. one that does not assume normal distribution, is the Wilcoxon signed-rank test (Vaughan, 2001; Field 2009). This test was performed using the Statistical

Package for Social Sciences, version 20 (SPSS, IBM Corp., Armonk, NY). It assumes that participants perceive the Likert scale steps as having the same size.

Effect size (ES), or the "standardized measure of the magnitude of observed changes" (Field, 2009) is computed as follows:

$$r = Z/(\sqrt{N}) \qquad (5.1)$$

where r is effect size, Z is the test result and N the total number of observations, i.e. twice the number of participants that took both the pre- and post-tests. The number of observations varies for each tested indicator as not all participants answered all questions. If an individual did not answer a question in either the pre- or the post test, that individual is not taken into account in the overall analysis concerning that indicator.

Since effective risk communication should take into account the characteristics of its target audiences, the dataset was split into age groups (adults, teenagers and children). To explain observed changes, the Wilcoxon signed-rank test was first applied to each age group for those indicators for which changes were measured for the whole sample. Further testing was conducted within each age group using the indicators that constitute the independent factors (Table 5.2).

In order to measure whether the observed effects of the exhibition remained after a few months, a second post-test was conducted with part of the group of children. Changes were determined both between the second and first post-tests and between the second post-test and the pre-test in order to assess whether there was a return to the initial level of awareness. Furthermore, the standard McNemar nonparametric statistical test for nominal data (here 1 = correct answer and 2 = wrong answer) in the context of a pre-test/post-test research design (Siegel & Castellan, 1988) was used to assess if there were significant changes in children's hard knowledge between the first and second post-tests.

5.3 CHARACTERISTICS OF THE PARTICIPANTS

5.3.1 Demographics

The sample as a whole accounts for around 9% of the population of the town of Barcelonnette (INSEE, 2012a). For teenagers and children, the sample is representative in terms of gender and age. The sample of adults is not representative in terms of age (INSEE, 2012b). This is due to the fact that the exhibition venue was only opened during working hours, preventing many employed adults to visit it and participate in the research activity. The adult sample is probably also not representative in terms of level of education because of the high proportion of participants that have a lower education level than the lowest level included in the questionnaire or who did not provide this information. Detailed demographics are presented in the Figure A7.1 of the Annex A7.

5.3.2 Prior Exposure to Awareness Raising

In Enders' framework (2001), the length of time living in an area is an indicator of the Exposure factor to awareness raising. More than 60% of the participants have been living in the Ubaye valley for more than 10 years or, for the children, since they were born (Figure 5.2). More than half of the adults have been living there for more than 20 years, therefore most participants were presumably exposed to prior awareness campaigns in the valley. Adults that do not live in the Ubaye valley are tourists mainly coming from the south of France. Seven teenagers come from the surrounding area (<60 km) and five from further away (max 160 km radial distance) (one did not specify). They spend at least the weekdays in the Ubaye valley as they were enrolled in a high school ski specialization.

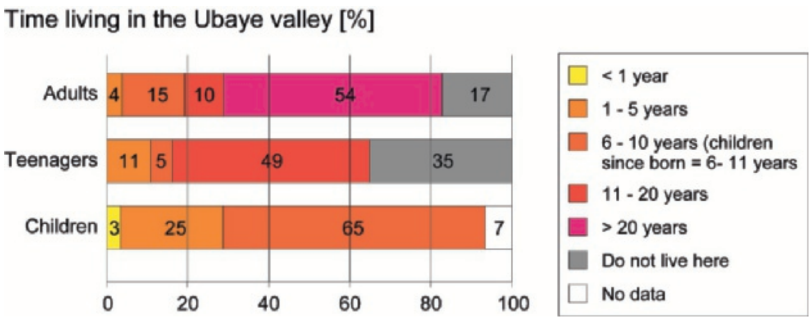


Figure 5.2: Exposure to awareness raising in terms of time living in the Ubaye valley.

The second indicator of exposure to awareness raising is the amount of information received regarding a particular hazard before the visit to the exhibition (Figure 5.3). Generally, participants had been informed most about avalanches and earthquakes and least on debris flows. There is no major difference between age groups, except the significant amount of information on avalanches received by the teenagers.

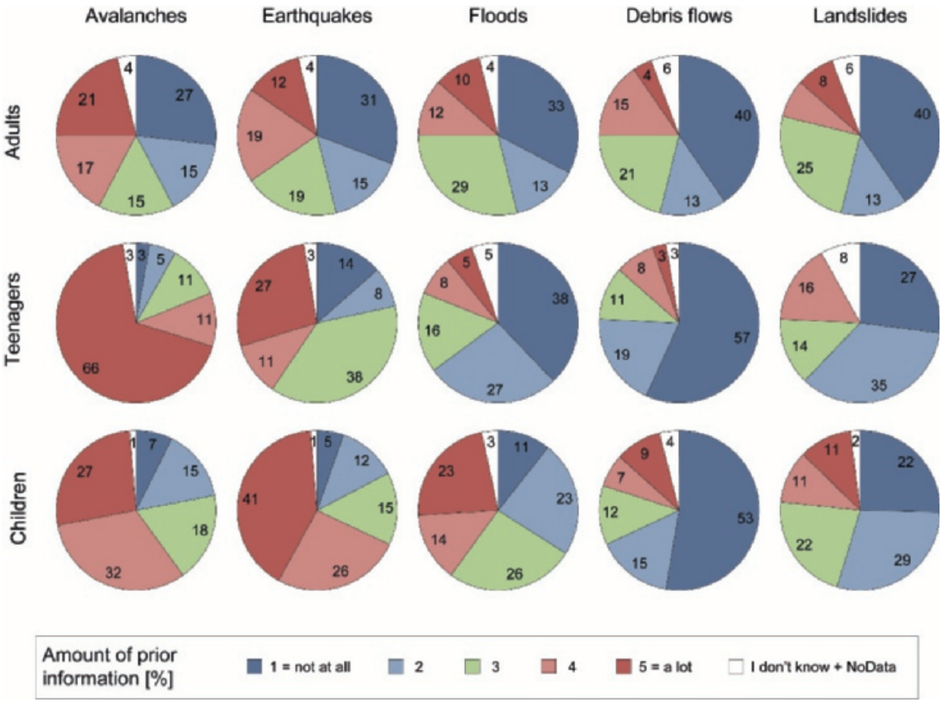


Figure 5.3: Amount of information (factor Exposure to awareness raising) received on each natural hazard by age group prior to the visit of the exhibition. Question: “How much information have you received on avalanches/earthquakes/floods/debris/landslides?” 5-points Likert scale: 1= not at all to 5=a lot.

In general, in pre-test results the participants did not clearly express a link between prior information and awareness or motivation to become prepared (Figure A7.2 in the Annex A7). However, it appears that for adults there is a connection between receiving prior information on avalanches and earthquakes, and awareness or motivation to become prepared for these hazards. For teenagers, the results suggest this connection for avalanches.

After the visit to the exhibition, participants were asked whether the exhibition provided them with new information about the concerned natural hazards; whether this new information made them more aware; and whether it motivated them to take action (asked of adults and teenagers only). The results show no clear tendency (Figure A7.3 in the Annex A7).

5.3.3 Previous Experience with Natural Hazards

The factor previous experience with natural hazards is constituted by direct and indirect experience indicators. In the first case, the number of times a given hazard was experienced and the personal impact (physical and resource wise) those hazard events had on the participant were measured. Most participants have experienced several natural hazards. But the hazard most often experienced by all groups is earthquakes (Figure 5.4). Concerning the other natural hazards considered, adults usually report most experience and teenagers least (Figure A7.4 in the Annex A7). The personal impacts of disasters, i.e. physical, damages to belongings, is usually low (Figure A7.5 in the Annex A7). The greatest personal impact was reported by adults in relation to earthquakes (10%) and by children in relation to earthquakes (30%), floods (13%) and landslides (13%). Overall, debris flows had the smallest personal impact on the participants.

Results for the indirect experience (Figure A7.5 in the Annex A7) show that only 6 to 8% of the adults, teenagers and children know people that have been impacted by debris flows. Fifteen to 17% of the participants know someone impacted by landslides. The indirect experience of earthquakes, floods, and avalanches is higher but never reaches more than 50%, with exception of indirect experience of teenagers with avalanches, which reaches 94%. This can be explained by the fact that they practice skiing intensively as part of their curriculum and are therefore in contact with the skiing community.

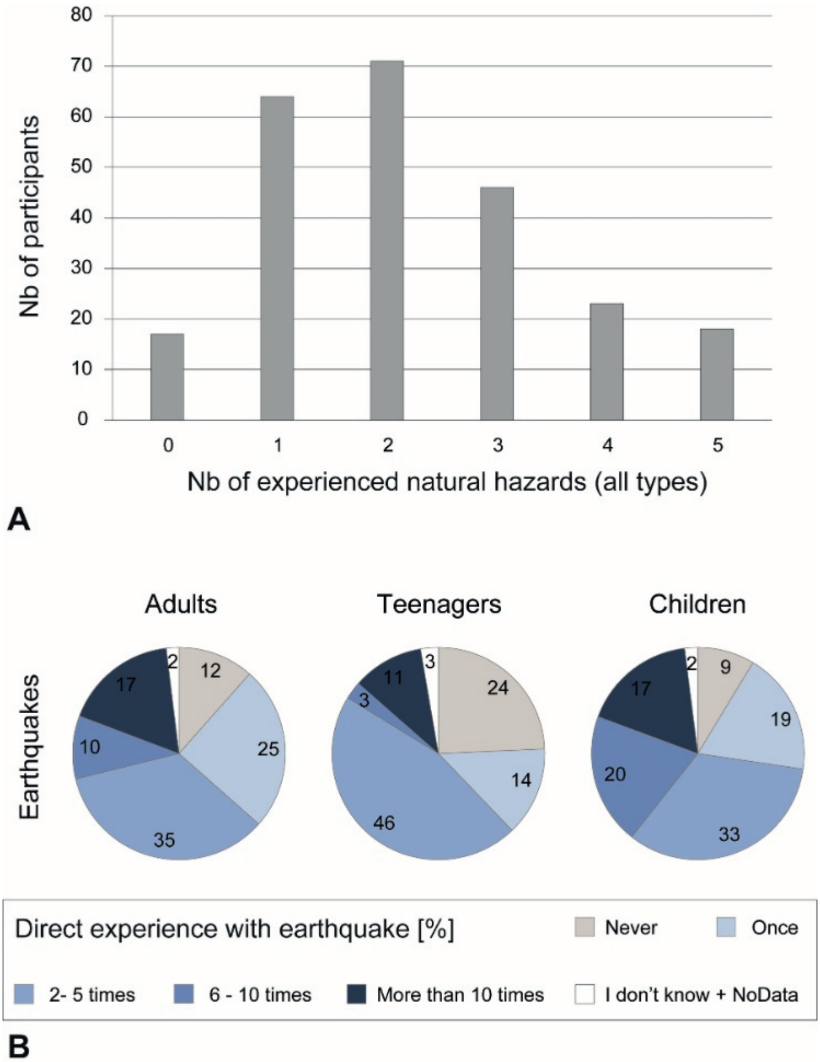


Figure 5.4: Number of hazards experienced by the participants (A) and direct experience with earthquakes (B). Results derived from the question "How often have you experienced the following natural hazards (avalanche/earthquakes/floods/debris/landslides?"

5.3.4 Hard Knowledge

Hard knowledge questions were asked in the post-tests only. All the answers could be found in the exhibition. As we did not measure the a priori knowledge, it is impossible to determine whether correct answers were due to the visit to the exhibition, prior knowledge or simply chance. All questions were multiple-choice, with 4 choices.

Adults and teenagers had about half of the answers right (Figure A7.6 in the Annex A7). Adults answered best to questions related to physical phenomena and risk management. Teenagers answered best (>80%) to the question related to avalanche risk scale, which again could be related to their ski sport specialization. Moreover, more than half of them answered the question on security guidelines correctly. Generally, children did not answer the knowledge questions very well in both the first post-test, conducted after the exhibition, and the second post-test, which was held 4-6 months later (<50% of correct answers). Only the question about the security guidelines shows a high percentage of correct answers for both tests. Between the two post-tests, the percentage of correct answers for four questions increased by 10%. This increase was not statistically significant according to the McNemar tests performed.

5.3.5 Information on Natural Hazard between the Two Post-tests

Generally, children that participated in the second post-test received little or no new information on the natural hazards between the two post-tests, except for earthquakes (Figure A7.7 in the Annex A7). The main sources of new information as reported by the children are the family, television and school. However, most children did discuss natural hazards after the visit, in particular with their parents and at school.

5.4 CHANGES IN AWARENESS

This section presents the results of the statistical analysis performed using the Wilcoxon signed-rank test for the total sample and by age group, as well as the effects of the explanatory factors.

5.4.1 Overall Measured Changes

Table 5.3 shows that significant changes occurred in the awareness of the participants due to the visit to the exhibition for ten out of the twenty indicators. Four out of five of the general indicators, those relating to hazards in general, present significant score' increases while this is only the case for six out of fifteen of the specific indicators, i.e. related to specific hazards. The observed effect of the exhibition's visit (i.e. effect size), given by r is small (<0.3) for most of these increases except for the feeling of being prepared and the perception of the severity of consequences linked to floods for which it is medium ($0.3 < r < 0.5$).

General indicators			Effect size (*r*)
Ability to mitigate/respond/prepare		Self-reported awareness	-0.14
		Self-reported vulnerability	-0.19
		Self-reported amount of know. and info.	-0.22
		Self-reported amount of resources	-
		Self-reported preparedness	-0.35
Worry level		Floods	-0.17
		Landslides	-
		Debris flows	-
		Earthquakes	-
		Avalanches	-
Specific indicators			Effect size (*r*)
Attitude to risks	Perceived likelihood	Floods	-0.23
		Landslides	-
		Debris flows	-
		Earthquakes	-
		Avalanches	-0.19
	Perceived consequences	Floods	-0.36
		Landslides	-
		Debris flows	-0.15
		Earthquakes	-
		Avalanches	-0.18

Table 5.3: Changes in awareness factors for the whole sample. All tests are based on negative ranks meaning that there are increases in scores between the two-tests. Significant changes are highlighted in light green for the small effects and in darker green for the medium effects. Complete test statistics in the Annex A7 (Table A7.1). Effect size r is given in Eq. (5.1).

5.4.2 Observed Changes by Age Group

Table 5.4 shows that these ten changes are not observed equally in all three age groups: only the perception of the severity of consequences linked to floods shows a significant increase for all age groups. Four indicators show a significant increase for two of the age groups (one for adults and teenagers, one for adults and children, and two for teenagers and children). The remaining five indicators show a significant increase for one age group only. Out of this total of sixteen significant increases, six have a medium and ten a small effect size.

<table>
<tr><td colspan="3" rowspan="2">General indicators</td><td colspan="3">Effect size (r)</td></tr>
<tr><td>Adults (pre-test/ post-test1)</td><td>Teenagers (pre-test/ post-test1)</td><td>Children (pre-test/ post-test1)</td></tr>
<tr><td colspan="2" rowspan="4">Ability to mitigate/respond/ prepare</td><td>Self-reported awareness</td><td>-.22</td><td>-.27</td><td>-</td></tr>
<tr><td>Self-reported vulnerability</td><td>-</td><td>-.25</td><td>-</td></tr>
<tr><td>Self-reported preparedness</td><td>-.31</td><td>-</td><td>-.24</td></tr>
<tr><td>Self-reported amount of know. and info.</td><td>-.31</td><td>-</td><td>-</td></tr>
<tr><td colspan="2">Worry Level</td><td>Floods</td><td>-</td><td>-.23</td><td>-.13</td></tr>
<tr><td colspan="6">Specific indicators</td></tr>
<tr><td rowspan="5">Attitude to risks</td><td rowspan="2">Perceived likelihood</td><td>Floods</td><td>-</td><td>-.30</td><td>-.12</td></tr>
<tr><td>Avalanches</td><td>-</td><td>-</td><td>-.19</td></tr>
<tr><td rowspan="3">Perceived consequences</td><td>Floods</td><td>-.30</td><td>-.34</td><td>-.2</td></tr>
<tr><td>Debris flows</td><td>-</td><td>-.45</td><td>-</td></tr>
<tr><td>Avalanches</td><td>-</td><td>-.28</td><td>-</td></tr>
</table>

Table 5.4: Changes in awareness factors by age group. All tests are based on negative ranks meaning that there are increases in scores between the two-tests. Significant changes are highlighted in light green for the small effects and in darker green for the medium effects. Complete test statistics in the Annex A7 (Table A7.2)

5.4.3 Effect of Explanatory Factors

The observed significant changes for each age group were analyzed with respect to the independent or explanatory factors (Tables 5.5, 5.6 and 5.7). Most of these changes have a medium effect size except for the children where lower effect sizes are more present.

ADULTS - Effect size (r)	Self-reported awareness	Self-reported preparedness	Self-reported amount of know. and info.	Perceived severity of the consequences of floods
Gender	Men: -.35	Women: -.41	Women: -.42	Women: -.31
Age	-	51-70 years old: -.35	-	>70 years old: -.35
Work related to natural hazards	-	No: -.41	No: -.32	No: -.31
Time living in the valley	-	Not: -.65	-	>20 years: -.33 Not: -.65
Last obtained degree	-	Unknown: -.42	-	Level II: -.58 Level V: .61 Unknown: -.51
Number of experienced natural hazards*	2: -.52	1: -.52 2: -.52	2: -.53	Yes: -.44
Suffered damages from the given number of natural hazards*	0: -.28	0: -.43	0: -.32	No: -.32
Knows people that suffered damages from the given number of natural hazards*	-	0: -.45	0: -.37	Yes: -.35
Prior total information**	2: -.44	1: -.6 2: -.6	1: -.55 2: -.46	1: -.68

* These variables are used differently depending if general or specific indicators are analysed. In the first case, they become "Number of hazard types, among the 5 possible, experienced", "Number of hazard types, among the 5 possible, that impacted health and properties" and "Number of hazard types, among the 5 possible, for which they know somebody that was impacted". In the second case, i.e. in relation to floods' consequences perception, they were transformed in dichotomous yes/no variables: "floods experienced or not", "Impacted by floods or not" and "Know somebody impacted by floods".

** This variable is modified when used to analysed general indicators. Likert scales scores (1 to 5) for each of the natural hazards are summed and subsequently categorized in 5 prior information levels (1 to 5 -> 1, 6-10 -> 2, 11-15 -> 3, 16-20 -> 4 and 21-25 ->5). This variable is raw, i.e. "prior amount of information received on floods" when used for analyzing the specific indicator.

Table 5.5: Changes in awareness factors for the adults. All tests are based on negative ranks meaning that there are increases in scores between the two-tests. Significant changes are highlighted in light, medium and dark green, corresponding to small, medium and large effect size. Complete test statistics in the Annex A7 (Table A7.3).

TEENAGERS *Effect size (r)*	Self-reported awareness	Self-reported vulnerability	Worry level related to floods	Perceived likelihood of floods	Perceived severity of the consequences of floods	Perceived severity of the consequences of debris flows	Perceived severity of the consequences of avalanches
Gender	Girls: -.35	-	-	-	Boys: -.41 Girls: -.49	Boys: -.36	Boys: -.35
Work related to natural hazards	No: -.32	-	-	-	No: -.46	No: -.27	No: -.34
Time living in the valley	Not: -.45	-	-	-	11-20 years: -.40 Not: =-.54	11-20 years: -.40	-
Number of experienced natural hazards *	1: -.56	-	-	No: -.32	No: -.45	No: -.29	No: -.37
Knows people that suffered damages from the given number of natural hazards*	-	-	No: -.36	No: -.48	No: -.51 Yes: -.42	No: -.25	-
Prior total information*	-	-	-	-	1: -.48	-	5: -.41

The "age" variable was not considered as all teenagers fall in the same category (<18 years old). Similarly, "Suffered damages from the given number of natural hazards" is not considered as only one teenager had been impacted. Moreover, for obvious reasons, the "diploma" variable is not considered as well. Please refer to footnotes of table 5.5 for the explanation on how some variable were modified (*).

Table 5.6: Changes in awareness factors for the teenagers. All tests are based on negative ranks meaning that there are increases in scores between the two-tests. Significant changes are highlighted in light, medium and dark green, corresponding to small, medium and large effect size. Complete test statistics in the Annex A7 (Table A7.4).

CHILDREN *Effect size (r)*	**Self-reported preparedness**	**Worry level related to floods**	**Perceived likelihood of floods**	**Perceived severity of the consequences of floods**	**Perceived likelihood of avalanches**
Gender	Boys: -.23 Girls: -.25	-	Girls: -.21	Boys: -.18 Girls: -.21	Boys: -.20 Girls: .18
Age	8 years old: -.40	10 years old: -.22	-	7 years old: -.45 8 years old: -.31	7 years old: -.45 9 years old: -.26
Time living in the valley	Since born: -.18 1-5 years: -.33	-	1-5 years: -.27	Since born: -.28	Since born: -.18
Number of experienced natural hazards *	No: -.52 1: -.31	No: -.15	No: -.15	Yes: -.38	No: -.27
Suffered damages from the given number of natural hazards*	0: -.31 2: -.53	No: -.16	No: -.16	Yes: -.51	No: -.20
Knows people that suffered damages from the given number of natural hazards*	0: -.27	No: -.20	No: -.16	No: -.14 Yes: -.30	No: -.21
Prior total information*	3: -.25 5: -.44	-	2: -.26	2: -.36	5: -.30

For obvious reasons, the "diploma" and "work related to natural hazards" variables are not considered. Please refer to footnotes of table 5.5 for the explanation on how some variable were modified (*).

Table 5.7: Changes in awareness factors for the children. All tests are based on negative ranks meaning that there are increases in scores between the two-tests. Significant changes are highlighted with three hues from light to dark corresponding to small medium and large effect size. Complete test statistics in the Annex A7 (Table A7.5).

5.4.3.1 Factor ‘Demographics’

Gender proved to be a significant explaining variable for all four significant scores’ increases in the adults group, for three of the seven significant score’ increases among the teenagers, and only one of five significant score’ increases for children. In five cases, the score’ increases were significant for females and in three cases for males. Moreover, older adults’ scores were significantly higher for self-reported preparedness and perception of the severity of floods in the post-test. Also among the children, age is significant for some changes. Furthermore, adults and teenagers that do not work or study in a field related to natural hazards scored significantly higher on seven of the eleven indicators than those who do. Finally, adults’ level of education seems to have some influence on two of the assessed changes.

5.4.3.2 Factor ‘Previous Experience’

Generally, adults, teenagers and children who had not experienced any natural hazards, or only a few, scored significantly higher. The exception was children who had experienced floods. Their perception of related consequences’ severity still increased significantly. Moreover, the adults and children who had not suffered any damage due to natural hazards, increased their scores between the two tests. Nothing can be said concerning teenagers as only two had been personally impacted.

Results related to the indirect experience with natural hazards are mostly similar, i.e. low experienced people scoring significantly higher in the post-test. However, adults that had knowledge of people affected by floods still increased their perception of the severity of the consequences linked to this hazard. The increase in this indicator were both significant for children and teenagers independently of whether they had indirect experience with this hazard or not.

5.4.3.3 Factor ‘Exposure to Awareness Raising’

In the few cases for which the time living in the valley produces changes in the dependent indicators, contrary effect appears. For both adults and teenagers, significant score’ increases between the tests were observed only for long-term residents in the valley and non-residents. Small increases were observed in the indicators for children born in the Ubaye valley or who have lived there for 1 to 5 years.

Overall, adults who reported low prior information levels on natural hazards (1 or 2 on 5) increased their scores significantly between the two tests. For teenagers, two situations occur. Concerning the consequences of floods, those whose level of prior information is low answered significantly higher in the post-test. Concerning the consequences of avalanches, the scores increased significantly for those with the highest level of prior information. Note that those constitute most of the surveyed teenagers. The same can be observed for the children (medium ES). For the other indicators, children with different levels of prior information (low, medium and high) increased their scores in the post-test.

5.4.4 Longitudinal Study – Observed Changes for the Children

Generally, there was no significant change between the two post-tests that the children took (Table A7.2 in the Annex 73). A significant decrease was only measured for the perceived likelihood of floods. This change was also observed between the pre-test and the second post-test. We can clearly observe variations in this change in terms of the gender (boys) and prior experience (none) (Table 5.8). Additionally, the self-reported preparedness significantly increased between the pre-test and both post-tests, but not between the two post-tests (Table A7.2 in the Annex A7), although this was not uniform among participants (Table 5.8).

CHILDREN	Self-reported preparedness (pre-test/2nd post-test)	Perceived likelihood of floods (pre-test/2nd post-test)	Perceived likelihood of floods (1st post-test/2nd post-test)
Gender	Boys: -.29 Girls: -.24	Boys: -.25	Boys: -.32
Age	10 years old: -.29	11 years old: -.63	8 years old: -.35
Time living in the valley	Since born: -.25	-	Since born: =-.28 1-5 year: -.33
Number of experienced natural hazards *	3: -.40	-	No: -.30
Suffered damages from the given number of natural hazards*	0: -.32 2: -.55	No: -.23	No: -.28
Knows people that suffered damages from the given number of natural hazards*	0: -.34	No: -.20	No: -.23 Yes: -.42
Prior total information*	3: -.25 5: -.42	-	2: -.30 4: -.49 5: -.44
Post total information*	2: -.33	3: -.48	3: -.37
Number of settings where natural hazard topic was discussed after the exhibition	1: -.35 2: -.36	-	2: -.39 3: -.25

* Please refer to footnotes of table 5.5 for the explanation on how some variable were modified (*). "Post total information" is modified according to the same logic.

Table 5.8: Longitudinal survey - Changes in awareness factors for the children. Green color = analysis based on negative ranks, i.e. it shows an increase between the two considered tests; orange color = analysis based on positive ranks, i.e. it shows a decrease between the two considered tests. Small effect size in light hues and for the medium effects in darker hues. Complete test statistics in the Annex

5.5 DISCUSSION

5.5.1 Overall Changes in Awareness

It appears that the visit to the exhibition triggered several changes in the immediate awareness of the participants and thus fulfilled its aim. When directly asked, participants reported only slightly increased awareness. However, the positive impact of the exhibition was revealed by the changes that were shown in the tests. This is particularly true for the factors that are not specific to particular natural hazards. Indeed, increases in the scores for feeling of being prepared and having all the knowledge and information to respond to natural hazards are signs that the exhibition had an effect. However, the feeling of having all the necessary resources to respond to natural hazards did not increase. This indicates that the feeling of being prepared depends largely on information and knowledge rather than on personal resources. Preparedness also depends on the concrete protective actions that are undertaken before a disaster occurs. Yet, as previous research suggests, being aware does not always induce such type of actions (Scolobig et al., 2012). Risk managers should therefore not rely only on the feeling of being prepared, but should also inform their audience that knowing about hazards is not enough and provide suggestions on what their audience can do to cope with a disaster. Although the feeling of being prepared increased, the feeling of being vulnerable increased as well. This can be interpreted positively as a realization of living in a risky area where disasters can take place and may lead to more protective behavior (Johnston et al., 1999).

It is known that perceptions about risks vary according to personal characteristics (Scolobig et al., 2012), but the evaluation of the “Alerte” exhibition showed that risk communication’s effects also depend on the type of natural hazard. Most significant score’ increases were measured for indicators related to emotions and attitudes towards floods (worry level, perceived likelihood of occurrence and perceived severity of consequences). Floods occur infrequently in the Ubaye valley (the last major flood occurred in 1957), and it is therefore not surprising that those indicators increased due to the visit. Moreover, direct observation and monitoring methods of the attractiveness of exhibits that complemented this study showed that the visitors found the flood scale model very attractive. The enhanced engagement with this exhibit may have led to an increased awareness of the risk of flood.

For the more frequently occurring (database of technical risk managers, i.e. Restauration des terrains en montagne – Office National des Forêts, confirmed by Flageollet et al., 1996) but also more localized hazards that are avalanches and debris flows, attitude to risk indicators, especially perceived severity of consequences, also showed significant scores' increases. Indicators related to natural hazards that are neither rare nor very frequent in the Ubaye valley, i.e. landslides and earthquakes, did not change. These results suggest that awareness raising programs, such as the exhibition, affect the attitude to risks related to hazards differently depending on likelihood and potential extent of consequences. Although some studies indicate that likelihood and magnitude have little effect on people's risk perception (Wachinger & Renn, 2010), it shows that risk communication should be tailored according to those aspects.

5.5.2 Seniors vs Juniors

The above-mentioned effects of the exhibition on the attitude to risks related to floods, debris flows and avalanches are mostly valid for teenagers and children and not for the group of adults, consisting mainly of senior citizens. This could be explained by the fact that adults have globally more experience with these hazards. Yet, the exhibition did have a more generic impact unrelated to specific hazards for the adults. The question is whether the lack of a more specific impact is due to the multi-hazard character of the exhibition. If yes, and if more specific impact is aimed for, risk communicators should complement multi-hazards risk communication practices by separate efforts specifically dedicated to a given hazard when they target this segment of the population.

Nonetheless, the generic effect of the exhibition was also observed for the younger participants. For example, particularly for the teenagers, increased self-reported awareness is associated with a realization of being vulnerable to natural hazards. It shows that risk communication efforts, such as this exhibition, can have considerable impacts on teenagers.

5.5.3 Changes Related to Demographics, Experience and Awareness Raising

The influence of demographics factors gender, age (within an age group) and education on the measured changes is ambiguous and difficult to explain. However, the analysis did show that the visit to the exhibition had a bigger impact on lay people than on specialists. This is neither surprising nor problematic since the aim of the exhibition was to raise the awareness of the general public.

The analysis shows that the exhibition was most effective for people with little experience, direct and indirect. This confirms that risk communication acts as a proxy of experience (Lindell & Perry, 2004: Maidl & Buchecker, 2015). In the light of those results, when selecting target audiences for awareness campaigns similar to the exhibition, priority should be given to people with little experience with natural hazards.

Most participants appear to have received a fair amount of information on natural hazards prior to the visit to the exhibition, especially on avalanches and earthquakes, but the impact of this information on prior Awareness and motivation to become prepared is not clear. This is also true for the impact of the information provided by the exhibition. However, Self-reported awareness and preparedness of the whole sample increased significantly between the pre- and the first post-test, but the detailed analysis shows these positive effects mainly for adults and teenagers who do not live in the Ubaye valley and who had little prior information on the considered natural hazards. Although it confirms that experience is one of the main factors of awareness (Scolobig et al., 2012), it is interesting to observe that visitors that had lived in this area for a long time also had increased scores concerning the perceived severity of consequences of floods, debris flows or avalanches, as if the exhibition acted as a reminder or “booster shot”. Significant changes were also observed for children who had previously received relatively much information. Hence, also for these groups an exposition may make sense.

5.5.4 Hard Knowledge

Due to potential bias, hard knowledge questions were asked only in the post-tests, and it was therefore not possible to assess the effect of the exhibition on this factor. However, some interesting age dependent observations can be made. Adults’ hard knowledge is historical, on specific events, and related to preparedness (security guidelines). Teenagers’ hard knowledge is more technical, such as seismic waves and avalanche risk indexes, and most probably linked to the education they received. They are enrolled in a ski specialization and earthquakes is a topic that is taught in the 8th grade French curricula (Ministère de l’Education Nationale, 2008). Prior knowledge can also explain the good score of children related to security guidelines. They had participated in an emergency exercise in their school during the year that preceded the visit to the exhibition.

More importantly, measuring the hard knowledge of the participants after the visit to the exhibition where they could find the answers to all questions, highlighted two very important misconceptions in the risk perception of the participants. The first is the idea, especially among teenagers and children, that avalanches and earthquakes are the most common natural hazards in the valley, while in fact this is debris flows. Secondly, debris flows are not well understood. They usually occur in summer, but most participants think they occur mainly in spring. Consequently, protective actions may not be taken at the right time. Since debris flows have a high-risk potential because they can occur suddenly at many places (Scolobig et al., 2012), future risk communication efforts should give priority to this hazard.

The idea of teenagers and children that avalanches and earthquakes are the most common natural hazards, can be explained by their experience with earthquakes and the ski specialization that the teenagers follow. The importance of direct experience and education is reinforced by the results provided by the comparison between children's hard knowledge answers of the two post-tests. The only questions for which the number of correct answers increased between the two tests are linked to natural hazards that took place or were discussed during this time. In the period between the two tests, an important earthquake occurred (7th of April 2014, magnitude 5.2, Bureau Central Sismologique Français, 2014). Moreover, children reported that they received more information on this hazard between the tests. In addition, two classes that took part in the study also participated in a national challenge (Ma ville se prépare,) for which they had to work on risk perception. Discussions with the teachers showed that they worked on the 1957 flood event, that they interviewed a witness chosen because the person had already been interviewed for the exhibition, and that almost every class that visited the exhibition was included in the activities related to the challenge.

5.5.5 Persistence of the Effect

The persistence of the effect of the exhibition was addressed by the longitudinal part of the study that involved the children (N=91). Three types of effects are visible. A long-term positive effect on self-reported preparedness as it remained at a higher level than before the visit to the exhibition. A short-time effect with negative effect is observed for perceived likelihood of floods. It first increased but in the second post-test dropped to below the initial level of the pre-test. Finally, the operationalization of a second post-test allowed to moderate the effects that have been measured for floods' worry, the perceived severity of consequences due to this hazard and the perceived likelihood of avalanches. The significant increases between the pre-test and the first post-test as well as the scores' stability between the two post-tests, indicate a long-term effect. However, the fact that there is no significant change between the pre-test and the second post-test suggests that the effect was only of short duration. Nevertheless, as the children who did not participate in the second post-test might have biased this stability analysis, caution is needed.

5.6 CONCLUSION

This study has shown that a one-way risk communication effort, i.e. an exhibition in a small mountainous town in the French Alps, can increase risk awareness of the general public. The research detected changes in factors that constitute awareness, which can help to prioritize risk communication efforts and risk communication research.

Changes were observed for general indicators of risk awareness, not related to any specific natural hazards and linked to preparedness. The feeling of being prepared and feeling of having all the knowledge and information to respond increased due to the visit to the exhibition. The feeling of being vulnerable increased as well, particularly for the teenage group, indicating a realization of the dangerous character of the place and a perception of higher risk. With respect to specific natural hazards, awareness of teenagers and children increased more than that of adults, mainly the perception of consequences. These results point out that while multi-hazard risk communication efforts are suitable for the younger age groups to increase their awareness of numerous natural hazards, more focused efforts might be appropriate for older people if the goal is to raise awareness of a given hazard. This indicates that a single awareness raising campaign, designed to meet the requirements of different groups in a community, is only advisable when resources are limited. In other cases, it is better to design various communication efforts. For example, in the context of this case study, a complementary effort targeting working population would have been valuable as the opening hours of the exhibition's venue were not suitable for this segment of the population.

This study also showed that the exhibition did not change the awareness regarding the different natural hazards to the same extent. More changes occurred for indicators related to the rare but potentially very destructive phenomenon of floods. The effects were lower or non-existent for more frequent or more localized hazards. These empirical observations indicate that when prioritization in developing risk communication efforts is required, preference should be given to extreme hazards events. Prioritization of target audiences can be conducted according to experience and education as this study confirmed that risk awareness is strongly influenced by those factors but that risk communication can act as a substitute for them. However, the results also showed that experienced and aware people benefited as well from this effort to raise awareness and therefore repeated campaigns are important.

Although the persistence of the effects of the exhibition for children is not obvious, direct observations and informal discussion with the children showed that the effect may have been more sustainable than could be measured by our research design. In addition, the latter did not allow measuring potential variations in hard knowledge, an important dimension of risk awareness, although the way it was taken into account unveiled some incorrect risk assessments of the participants. This calls for further research on methodological improvement, including the analysis of biases related to how the survey is conceived and assumptions behind the use of appropriate statistical tests. Further research in similar and different settings and on different natural hazards is needed to increase the knowledge of how to operationalize the measurement of changes in the mental construct of risk awareness in its full complexity. Moreover, additional efforts are required to allow the systematic conduct of longitudinal studies to measure long term effects of awareness raising campaigns related to natural hazards risks. In the context of multi-hazard risk communication related to natural hazards, the link between awareness and taking preparatory actions should also be addressed. As confirmed by this study, multi-hazard risk communication can increase the feeling to be prepared in general. Further studies should assess if risk communication can also result in behavioral change.

This study should be seen as a contribution towards the highly important task of science to analyze the effectiveness of multi-hazard risk communication efforts targeting a community as a whole. Moreover, it is an example of how scientists not only took on the role of communicators, but also conducted research regarding their own actions. From the perspective of the inclusion of stakeholders in the process, the project was highly successful and calls for more practices where both real communication campaigns and research are carried out simultaneously.

5.7 REFERENCES

Anginard, M. (2011). Applying risk governance principles to natural hazards and risks in mountains. Doctoral dissertation, Technische Universität Dortmund.

Atman, C.J., Bostrom, A., Fischhoff, B., & Morgan, M.G. (1994). Designing risk communications: completing and correcting mental models of hazardous processes, Part I. Risk Analysis, 14(5), 779-788.

Breakwell, G.M. (2000). Risk communication: factors affecting impact. British Medical Bulletin, 56(1), 110-120.

Bell, R., & Glade, T. (2004). Multi-hazard analysis in natural risk assessments. WIT Press, Boston, 132 p.

Bier, V.M. (2001). On the state of the art: risk communication to the public. Reliability engineering & system safety, 71(2), 139-150.

Bubeck, P., Botzen, W.J., & Aerts, J.C. (2012) A review of risk perceptions and other factors that influence flood mitigation behavior. Risk Analysis, 32(9), 1481-1495.

Bureau Central Sismologique Français. Macroseismic database. (2004). http://www.franceseisme.fr/donnees/intensites/details_seisme.php?IdSei=497 (last accessed on the 01.07.2017).

Burningham, K., Fielding, J., Thrush, D. (2008) ‘It'll never happen to me’: understanding public awareness of local flood risk. Disasters, 2008; 32(2): 216-238.

Charrière, M.K.M., Junier, S.J., Mostert, E., & Bogaard, T.A. (2012). Flood risk communication – Visualization tools and evaluations of effectiveness. Proceedings of the 2nd European Conference on FLOODrisk Management, November 20-22, 2012, Rotterdam, The Netherlands.

Chao, L.W., Gow, J., Akintola, O., & Pauly, M.V. (2010) A comparative evaluation of two interventions for educator training in HIV/AIDS in South Africa. International journal of education and development using information and communication technology, 6(1), 1-14.

Checkland, P., & Holwell, S. (1998). Action research: its nature and validity. Systemic Practice and Action Research, 11(1), 9-21.

Cohen, B.H., & Lea, R.B. (2004).Essentials of statistics for the social and behavioral sciences. Vol. 3. John Wiley & Sons, 291 p.

Covello, V., Fisher, A., & Bratic Arkin, E. (1991) Evaluation and effective risk communication: introduction, in: Evaluation and Effective Risk Communications Workshop Proceedings, xi-xvii, edited by: Fisher, A., Pavlova, M., and Covello, V., Cincinnati, Ohio, USA.

Covello, V., & Sandman, P.M. (2001). Risk communication: evolution and revolution. Solutions to an Environment in Peril, 164-178.

Davis, I., Hosseini, M., & Izadkhah, Y.O. (2003). Public awareness and the development of a safety culture: key elements in disaster risk reduction. In: Proceedings of the 4th International Conference on Seismology and Earthquake Engineering (SEE 4), 12-14 May 2003, IIEES, Tehran, Iran.

Enders, J. (2001) Measuring community awareness and preparedness for emergencies. Australian Journal of Emergency Management, 52-59.

Field, A. (2009) Discovering statistics using IBM SPSS statistics. 3rd edition, Sage, 856 p.

Fischhoff, B. (2012). Communicating Risks and Benefits: An Evidence Based User's Guide. Government Printing Office.

Flageollet, J.-C., Maquaire, O., & Weber, D. (1996). The temporal stability and activity of landslides in Europe with respect to climatic change. Final National Report, 86 p.

Frewer, L. (2004). The public and effective risk communication. Toxicology letters, 149(1), 391-397.

Höppner, C., Buchecker, M. & Bründl, M. (2010). Risk communication and Natural Hazards, CapHaz-Net - Social Capacity Building for Natural Hazards - Toward More Resilient Societies, vol CapHaz-Net WP5 report, Birmensdorf, Switzerland.

Höppner, C., Whittle, R., Bründl, M., & Buchecker, M. (2012). Linking social capacities and risk communication in Europe: a gap between theory and practice? Natural Hazards, 64, 1753–1778.

INSEE (2012a). Evolution et structure de la population en 2012 – POP1B – Population par sexe et âge – Commune de Barcelonnette, 2005. http://www.insee.fr/fr/themes/tableau_local.asp?ref_id=POP1B&millesime=2012&niveau=1&typgeo=COM&codgeo=04019 (last consulted on the 19th of August 2015).

INSEE (2012b). Evolution et structure de la population en 2012 – Chiffres clés Diplômes - Formation – Commune de Barcelonnette, 2005. http://www.insee.fr/fr/themes/tableau_local.asp?ref_id=FOR&nivgeo=COM&codgeo=04019&millesime=2012 (last consulted on the 19th of August 2015).

Johnston, D.M., Bebbington Chin-Diew Lai, M.S., Houghton, B.F., & Paton, D. (1999). Volcanic hazard perceptions: comparative shifts in knowledge and risk. Disaster Prevention and Management: An International Journal, 8(2), 118-126.

Kellens, W., Terpstra, T., & De Maeyer, P. (2013). Perception and communication of flood risks: a systematic review of empirical research. Risk Analysis, 33(1), 24-49.

Keller, C., Siegrist, M., & Gutscher, H. (2006). The role of the affect and availability heuristics in risk communication. Risk analysis, 26(3), 631-639.

Kuhlicke, C., Steinführer, A., Begg, C., Buchecker, M., De Marchi, B., Höppner, C., Komac, B., McCarthy, S., Renn, O., Tapsell, S., Wachinger, G., Walker, G., & Whittle, R. (2010). Knowledge inventory - State of the art of natural hazards research in the social sciences and further research needs for social capacity building. CapHaz-Net WP10 Report, Leipzig, Germany.

Leiss, W. (1996). Three phases in the evolution of risk communication practice. Annals of the American Academy of Political and Social Science, 545, 85-94.

Lindell, M.K., & Perry, R.W. (2003). Communicating environmental risk in multiethnic communities. Vol. 7. Sage Publications, 272p.

Loewenstein, G.F., Weber, E.U., Hsee, C.K., Welch, N. (2001) Risk as feelings. Psychological bulletin, 127(2), 267-286.

Lundgren, R., & McMakin, A. (2004). Risk communication - A Handbook for communicating environmental, safety and health risks. Battelle Press, Colombus, USA, 453 p.

Maidl, E., & Buchecker, M. (2015) Raising risk preparedness by flood risk communication. Natural Hazards and Earth System Science, 15(7), 1577-1595.

McCallum, D.B. (1995). Risk Communication: a tool for behaviour change. In: Backer TE, David SL, Saucy G, editors. Reviewing the behavioural science knowledge base on technology transfer, NIDA Research Monograph, 155, 65-89.

Miceli, R., Sotgiu, I., & Settanni, M. (2008). Disaster preparedness and perception of flood risk: A study in an alpine valley in Italy. Journal of Environmental Psychology, 28(2), 164-173.

Ministère de l'Education Nationale. (2008). Programmes du collège – Programmes de l'enseignement de sciences de la vie et de la Terre. Bulletin officiel spécial, 6.

Neresini, F., & Pellegrini, G. (2008). Evaluating public communication of science and technology. In: Bucchi, M., & Trench, B., (eds.) Handbook of public communication of science and technology. Routledge, New York, USA, 237-251.

OECD. (2007). Climate Change in the European Alps Adapting Winter Tourism and Natural Hazards Management: Adapting Winter Tourism and Natural Hazards Management, OECD Publishing.

Penning-Rowsell, E., & Handmer, J. (1990). The changing context of risk communication In: Handmer, J., and Penning-Rowsell, E. (eds.) Hazards and the communication of risk. Gower Technical.

Plough, A, & Krimsky, S. (1987). The emergence of risk communication studies: social and political context. Science, Technology, & Human Values, 12(3/4), 4-10.

Rohrmann, B. (1992). The evaluation of risk communication effectiveness. Acta Psychologica, 8,169-192.

Rohrmann, B. (1998). Assessing hazard information/communication programs. Australian Psychologist, 33(2), 105-112.

Scolobig, A., De Marchi, B., & Borga, M. (2012). The missing link between flood risk awareness and preparedness: findings from case studies in an Alpine Region. Natural hazards, 63(2), 499-520.

Siegel, S., & Castellan Jr, N.J. (1988). Nonparametric statistics for the behavioral sciences. McGraw-Hill Book Company, 2nd edition, Chapter 5, The case of one sample, two measures or paired replicates; pp. 73-101.

Siegrist, M. (2013). The necessity for longitudinal studies in risk perception research. Risk analysis, 33(1), 50-51.

Slovic, P. (1987). Perception of risk. Science, 236(4799), 280-285.

Slovic, P., Finucane, M.L., Peters, E., & MacGregor, D.G. (2007). The affect heuristic. European journal of operational research, 177(3), 1333-1352.

Small, S. A., & Uttal, L. (2005). Action-oriented research: Strategies for engaged scholarship. Journal of Marriage and Family, 67(4), 936-948.

Terpstra, T., Lindell, M.K., & Gutteling, J.M. (2009). Does Communicating (Flood) Risk Affect (Flood) Risk Perceptions? Results of a Quasi-Experimental Study. Risk Analysis, 29(8), 1141-1155

UNISDR (2009). UNISDR terminology on disaster risk reduction. Geneva, Switzerland.

UNISDR. (2015). Proposed Updated Terminology on Disaster Risk Reduction: A Technical Review.

Vaughan, L. (2001). Statistical methods for the information professional: A practical, painless approach to understanding, using, and interpreting statistics. Vol. 367. Information Today, Inc., 209 p.

Wachinger, G., & Renn, O. (2010). Risk perception and natural hazards. CapHaz-Net WP3 Report.

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

Zingari, P.C., & Fiebiger, G. (2001). Mountain risks and hazards. Unasylva, 208: 71-77.

6. Using radio-frequency identification technology and a survey to assess how exhibits attract, retain the attention and satisfy visitors of an exhibition on natural hazards

6.1 INTRODUCTION

One of the criteria for an effective communication tool is its reach (Austin & Pinkleton, 2015, p.60). In the context of an exhibition, reach can be defined as the number of visitors that the different exhibits attract and the time they spend at the exhibits.

Studies on timing and tracking to analyze the behavior of visitors in a museum or exhibition setting have been used for at least a hundred years (Bollo & Dal Pozzolo, 2005; Yalowitz and Bronnenkant, 2009). Such studies allow to pinpoint the preferences and interest of visitors, as it can be assumed that the time spent at an exhibit reflects their preferences and interests (Kanda et al., 2007). These studies also enable to determine how people move at an exhibition, to highlight the "facts and actions that are preconditions for learning" (i.e. noticing an exhibit and look at it for the time that is necessary to absorb the content: Bollo & Dal Pozzolo, 2005, p.2-3), to assess its success, and to inform future initiatives (Yalowitz and Bronnenkant, 2009).

In the case of an exhibition on natural hazards knowing which exhibits retain the attention of the visitors is very informative for risk communication. Visitors can freely move and spend time at the exhibits of their choice (Klein, 1993). As the aim of such exhibitions is often to raise risk awareness and foster protective attitudes and behaviors, observing the choices of visitors can provide insight on which communication tools are most effective.

Assessing the spatial behavior of visitors by means of questionnaires depends on the honesty and memory of the participants (Modsching et al., 2008), the reliability of which is hard to quantify. Radio Frequency Identification (RFID) may be a better option. RFID is a wireless tracking technology that exploits radio waves to collect data from an identification chip (Wu et al., 2009). In simple terms, RFID can measure when and how long a given tag passes in front of a reader. It has many applications, e.g., in the retailing industry, logistics, food and restaurant industry, healthcare, ticketing, toll systems or crowd control (Wu et al., 2009; Mohandes, 2010; Zhu et al., 2012). In exhibitions or museums, RFID technology can be used to model visitors' behavior and enhance the interactivity of the visit (e.g. Bannon et al., 2005; Hsi and Fait, 2005; Solic et al., 2009). It has several advantages compared to other observational tools. Direct observation with a paper-and-pencil method depends on human resources and thus can be less effective as one observer can track only a limited number of visitors at a time. Video recording of visitors is another possibility but cannot always be pursued due to restrictive privacy laws. This is for example the case in France, where part of our study took place. Finally, GPS-based methods are not yet able to measure precise movements in a small indoor space (Siavesh Shakeri, PhD student at the Geoscience & Remote Sensing Department, Citg, TUDelft, 2013, personal communication).

However, tracking technologies like RFID do not allow one to assess the perceptions of the visitors. There is a need to complement the tracking information with a questionnaire-based survey after the visit of the exhibition to obtain information on their satisfaction and opinions. In addition, a questionnaire-based survey can help understand whether the exhibition enabled learning, changed opinions and caused surprises.

This chapter aims, first, to analyze the usefulness of RFID technology for tracking visitors at an exhibition and analyzing the time-spent at the different exhibits. Secondly, it aims to assess the usefulness of this technology in combination with a satisfaction survey for increasing insight in which risk communication tools are most effective to attract and hold attention at an exhibition.

After explaining the methodology used to time and track the visitors in the exhibition as well as the survey that was conducted (section 6.2), the results are presented (section 6.3). The discussion and concluding remarks (sections 6.4 and 6.5) discuss the usefulness of combining these two methods for gaining more insight and improving the effectiveness of exhibitions that aim to increase awareness of natural hazards.

6.2 METHODOLOGY

6.2.1 Exhibitions Set-up and Participants

The exhibitions where RFID technology was tested were the 'Alerte' exhibitions in France and Romania. The Alerte exhibition in France has been described in chapters 4 and 5. The exhibits in Romania (Figure 6.1) were partly the same, i.e. posters on introductory concepts, landslides, floods and debris flows, earthquakes, structural and non-structural mitigation measures, as well as an emergency kit. The videos of natural hazards' events were in both exhibitions of local and foreign events. One local important natural hazard was added to both exhibitions using posters: snow avalanches in France and forest fires in Romania. In Romania posters were also used to show anaglyph 3D maps of landslides and to present the results of the European research project "Changes" in which this study was embedded. The French exhibition was more extensive and interactive as a flood scale model, a seismograph, an interactive map, a selection of on-demand videos of testimonies as well as a digital timeline of historical events were included. This timeline was also available on a large poster. The interactive components were not included in the Romanian exhibition. The participants in this study in both France and Romania were children, teenagers, young adults and adults (Table 6.1).

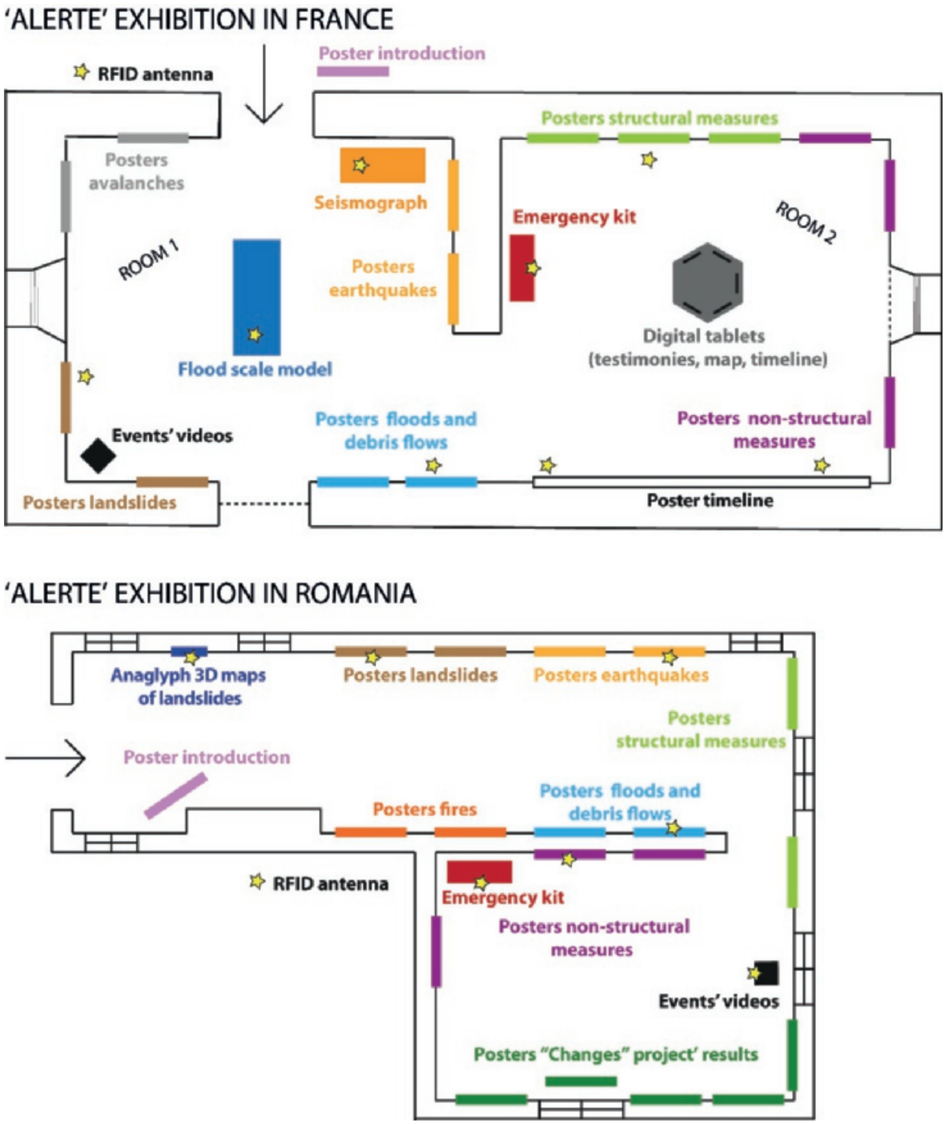


Figure 6.1: 'Alerte' exhibition's maps in France and in Romania with the respective exhibits. RFID antennas are marked using the yellow stars.

	Children		Young adults/teenagers		Adults	
	France	Romania	France	Romania	France	Romania
RFID	150	205 (110 for the 3D Maps)	37	8	51	17
Satisfaction survey	150	110	37	8	102	10

Table 6.1: Distribution of the participants in the study by age group.

6.2.2 Timing and Tracking using Radio-Frequency Identification

The RFID appliances that we used for this research were antennas (seven in Romania and eight in France) linked to a reader and passive tags embedded in badges that were given to the participants (Figure 6.2). The antennas (yellow stars in Figure 6.1) were placed to (1) cover as much exhibition space as possible, (2) cover diverse exhibits and (3) comply with technical issues (i.e. reach of the antennas, cable length, and presence of interfering materials such as metal tables).

Figure 6.2: RFID appliances from left to right: an antenna, the reader, a passive tag embedded in a badge.

Trials conducted at the French exhibition revealed that a tag can only be detected when it is within a few meters (approximately 1-2 meters) of an antenna and when there is a free line of sight. This means the tag the visitor carried was not always seen by the antennas, e.g. when shielded by the visitor's body or when the tag was under a wrong angle with the antenna. This results in a dataset of discontinuous detections of a specific tag at a certain antenna (so-called entries), typically on the order of several seconds. In other words, if a tag is recorded by an antenna, one is sure it is in sight of an antenna, but if the tag is not recorded by any antenna, it is unknown where it is, meaning the position of the visitor (tag) should be interpolated.

The raw RFID data collected consisted of the tag ID number, the antenna where the tag was detected, the time stamp of the entry with the time of the first detection and of the last detection, the timespan between the two in seconds, and the number of times the tag is seen in this timespan (Figure 6.3).

	A	B	C	D	E	F
1	**Tag number**	**Antenna**	**First seen**	**Last seen**	**Timespan (in seconds)**	**Read count**
2	1003	4	15-11-2013 15:42	15-11-2013 15:42	0	1
3	1003	3	15-11-2013 15:42	15-11-2013 15:42	3	3
4	1006	3	15-11-2013 15:41	15-11-2013 15:41	1	4
5	1006	3	15-11-2013 15:41	15-11-2013 15:41	15	18
6	1006	4	15-11-2013 15:41	15-11-2013 15:42	50	83

Figure 6.3: An example of the raw RFID data collected in a spreadsheet.

To obtain information on the time each visitor was at an exhibit or on the visitors' path, the database needed to be filtered and processed. Some assumptions had to be made. First, a preliminary analysis of the raw data was required to define the threshold time to move from one exhibit to another. In this case, based on the French dataset, if the time between two entries by one identical antenna is less than 30 seconds, the visitor is assumed to have stayed near the antenna and not to have walked away unnoticed by other antennas and returned to the exhibit.

Second, the time spent in each of the two rooms was assessed by calculating the time span between the first time a person is seen by an antenna in the first room and the first time the same person is seen by an antenna in the second room and vice versa. For an exhibit too big to be measured with just one antenna (the timeline poster), the time spent looking at it is estimated by the time difference between the first entry detected at the antenna located at the beginning of the exhibit and the last entry detected at the antenna located at the end of the exhibit.

Moreover, data filtering and processing allowed to estimate the time spent at exhibits that are not in the range of any antenna. For example, in the French exhibition the presence of metal prevented the use of an antenna near the digital tablets (videos of testimonies, interactive map and digital timeline) in room 2. Therefore, the total time spent in front of the digital tablets was calculated by subtracting the time spent at the antennas in room 2 from the total time spent in room 2. This duration is overestimated as it may account for the time people were transiting or were not being recorded by the other antennas due to blockage of their line of sight. Therefore, the time spent at the digital tablets is scaled using a recording factor. Assuming that the behavior in room 2 is the same as in room 1, this factor is calculated as the average of the total time spent in room 1 by the sum of time spent in front of all the antennas in room 1.

This processing was used to calculate four timing and tracking measures that are related to a “stopping behavior”, i.e. “where people went, where they stopped and how they spent their time” (Yalowitz and Bronnenkant, 2009; p.49):

(1) Attraction power, i.e. the proportion of visitors who stop at a specific exhibit for a minimum amount of time (Klein, 1993; Sandifer, 2003; Bollo & Dal Pozzolo, 2005; Yalowitz and Bronnenkant, 2009) was calculated as follows:

$$Attraction\ power = \left(\frac{Number\ of\ stopping\ visitors}{Total\ number\ of\ visitors}\right) * 100 \qquad (6.1)$$

In our study, we used five seconds, as the threshold to differentiate between “stopping” and “passing by” (Boisvert & Slez, 1995; Solic et al., 2009).

(2) Average holding time, i.e. the average time visitors spend in front of a given exhibit (Shettel, 1997; Sandifer, 2003), in seconds:

$$Average\ holding\ time = \frac{Total\ number\ of\ seconds\ spent\ in\ front\ of\ a\ given\ exhibit}{Number\ of\ times\ visitors\ were\ recorded\ at\ the\ same\ exhibit} \qquad (6.2)$$

(3) Holding power, i.e. the ratio between the average time spent in front of an exhibit and the time that is defined as required to fully "visit" this exhibit (Shettel, 1997; Sandifer, 2003):

$$Holding\ power = \frac{Average\ time\ spent\ in\ front\ of\ an\ exhibit}{Time\ required\ to\ visit\ the\ exhibit} \tag{6.3}$$

The time required to visit the exhibits (Figure 6.4) was estimated based on direct observations of the visitors as well as personal test by the researchers. For the videos, it is their total duration.

(4) Average duration (i.e. minutes) spent in each room of the exhibition.

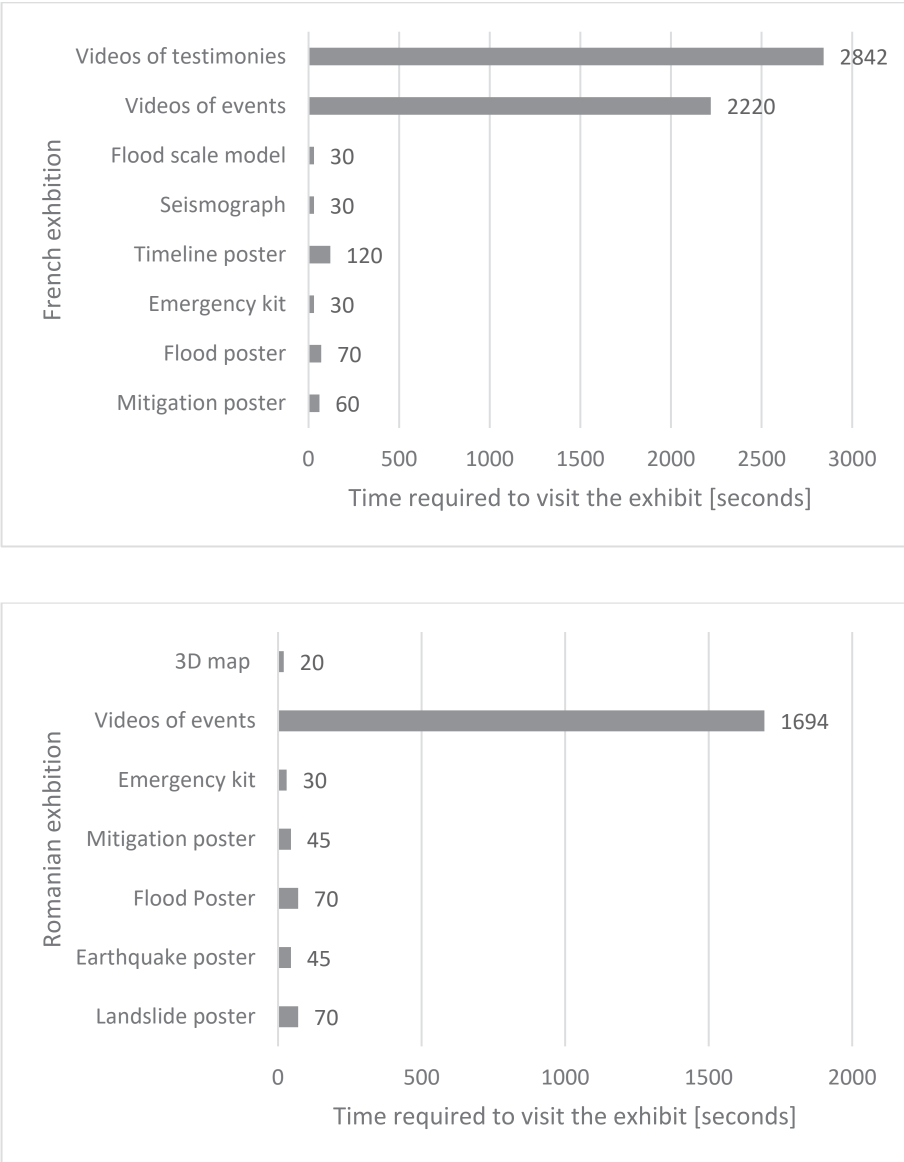


Figure 6.4: Estimated time in seconds required to "visit" each exhibit in the French (top) and Romanian (bottom) exhibition, used for calculating the holding power of each exhibit.

6.2.3 Satisfaction Survey

The satisfaction survey is composed of two 5-points Likert scale questions with several items (Table 6.3). One item of the first question was not asked to the children as it was assumed to be too difficult to answer. Since we cannot be certain that participants interpreted all steps of the 5-points Likert scale in the same way, usual descriptive statistics (i.e. mean, standard deviation, etc) cannot be used. The data are thus represented using bar plots and interpreted qualitatively. To overcome the fact that age groups are varying at lot in terms of size, percentages are used.

Questions	**Items**	
Do you agree with the following? **(1= not at all, to 5=completely)**	Both French and Romanian surveys: • I liked the exhibition • This exhibition changed my views on natural hazards and associated risks • I learned new things • The content of the exhibition surprised me • The presentation of the exhibition is appropriate *(not asked to the children)*	
Did you like the different items? **(1= not at all, to 5=a lot)**	French survey: • Posters on emergency guidelines • Posters on mitigation measures • Posters on phenomena • Emergency kit • Interactive timeline • Poster of the timeline • Interactive map • Seismograph • Flood scale model • Videos of events • Videos of testimonies	Romanian survey: • Posters on emergency guidelines • Posters on mitigation measures • Posters on phenomena • Emergency kit • Anaglyph 3D map • Videos of events

Table 6.3: Satisfaction surveys' questions and related items.

6.3 RESULTS

6.3.1 Radio Frequency Identification

6.3.1.1 French Exhibition

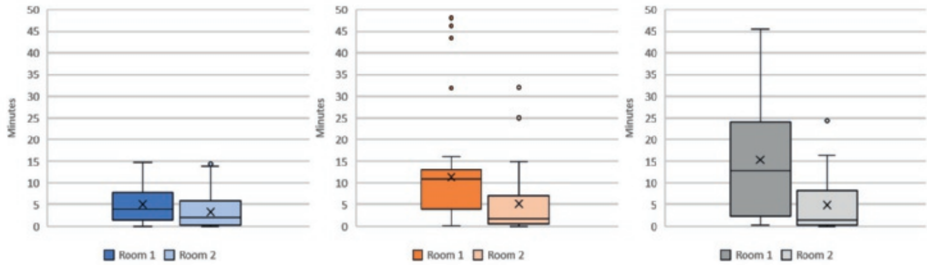


Figure 6.5: Time and tracking variable Time spent in each room for the French 'Alerte" exhibition. Left: children (n=148/n=136) Middle: teenagers (n=37/n=34). Right: adults (n=51/n=43)

The time spent in the first room of the exhibition (Figure 6.5) increases with age. While children spent on average five minutes in it, the teenagers spent in average more than 11 minutes and the adults more than 15 minutes. The time spent by each age group in room 2 is more comparable between age groups: between three and six minutes on average. While the time spent in room 1 is greater than in room 2 for all groups, this difference increases with age, with the children spending 1.5 more minutes in room 2, the teenagers 6 minutes more and the adults 9 more minutes. Moreover, the spread of the distributions for each age groups increases with age. This indicates that the variability of behavior in terms of time spent in the exhibition, and in particular in room 1, grows with the age of the visitors.

Children and teenagers were more attracted to the interactive exhibits (i.e. seismograph, flood scale model, video events and digital tablets) presented in each room than to the static ones (i.e. the posters and emergency kit) (Figure 6.6, top graph). The attraction power of the poster timeline seems to contradict this. However, the latter was positively influenced by the location of this exhibit, as it was along the wall between the two rooms. Whether there is a difference in attraction power between static and interactive exhibits is not so clear for the French adults. They are similarly attracted as children and teenagers to the poster with mitigation measures, the emergency kit, and the videos of events and the digital tablets. While the poster of the timeline seems to be a little more attractive for the adults, the flood poster is clearly much more attractive for them. Contrarily, adults are less attracted by the flood scale model and especially the seismograph.

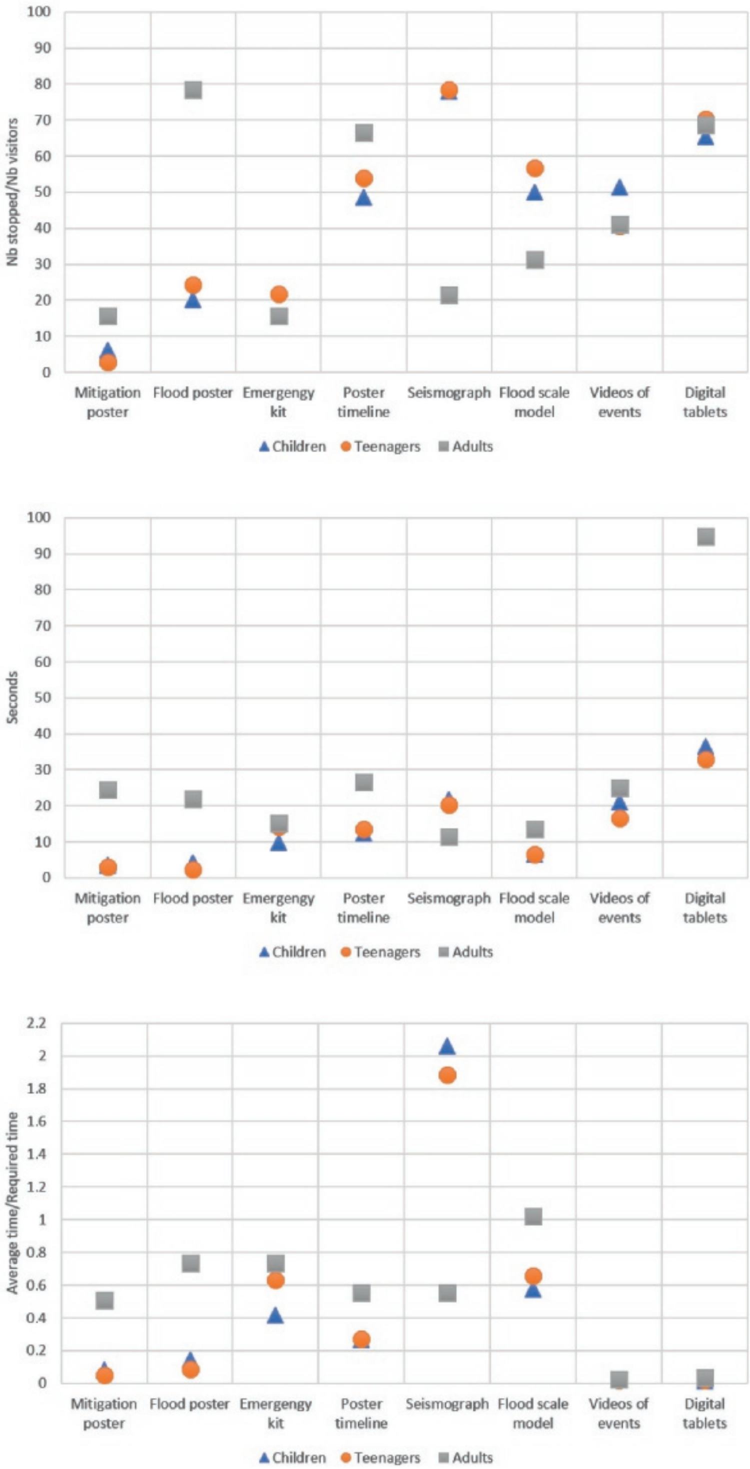


Figure 6.6: Time and tracking variable for each exhibit of the French 'Alerte" exhibition. Top: attraction power, middle: average holding time and, bottom: holding power.

Generally, the average holding time of the exhibits was under 30 seconds (Figure 6.6, middle graph), except for the digital tablets. The latter were visited for the longest duration, especially by the adults. To a lesser extent, adults visited all the exhibits longer than the children and teenagers, except for the seismograph. The emergency kit as well as the flood scale model also held the adults' attention for relatively short time. It is not surprising that the tablets had the higher average holding time as they presented many items (15 interviews, a digital timeline and an interactive map). After the digital tablets, the exhibits with the highest average holding times for the adults were those containing videos or text and not objects, independently of their static or interactive characteristic. For children and teenagers, average holding times of the interactive exhibits were the highest, except for the only exhibit that needed to be operated by the scientist, i.e. the flood scale model. The average holding time of posters for children and teenagers, except for the poster timeline, was less than five seconds, indicating that they were rather passing by than stopping in front of these exhibits.

Generally, and independently of the time spent in front of them, the exhibits were visited for shorter times than the estimated duration required to fully appreciate them, i.e. the holding power (Figure 6.6, bottom graph). Only the seismometer held the attention of children and teenagers approximately twice the time required to visit it, which is estimated to be one of the shortest (Figure 6.4). Even though digital tablets were the exhibits in front of which visitors spent the longest time, their holding power is quite low, similarly as for the other videos.

6.3.1.2 Romanian Exhibition

In Romania, the organization of the visits to the exhibition resulted in a large number of visitors at the same time. This, combined with a set-up of the exhibition rooms that did not allow fluent passing of the people, generated traffic jams of visitors stuck in front of an RFID antenna waiting to go further without necessarily looking at the exhibit. Therefore, the raw data were filtered for groups of visitors and only average holding times and the holding power were determined. Still, these results should be taken with caution as they are likely overestimating the real holding time and power.

Depending on the age group, people spent different amounts of time at the exhibition. On average, the young adults spent a bit less than 24 minutes, the adults approximately 15 minutes, and the children approximately 10 minutes (Figure 6.7, top graph). For most of the exhibits the average holding time for the different age groups varies less than 10 seconds (Figure 6.7, middle graph): between 10 and 20 seconds for the posters on landslide and earthquake hazards, between 10 and 15 seconds for the poster on mitigation measures, between 5 and 15 seconds for the one on floods, and less than 10 seconds for the emergency kit and the 3D map. However, adults (emergency kit) and adults and young adults (3D map) spent on average less than 5 seconds in front of the latter two, so we can consider that most just passed by and did not stop. Similarly, young adults did not seem to stop by the videos of events. On the contrary, this was the exhibit that the children spent most time in front of.

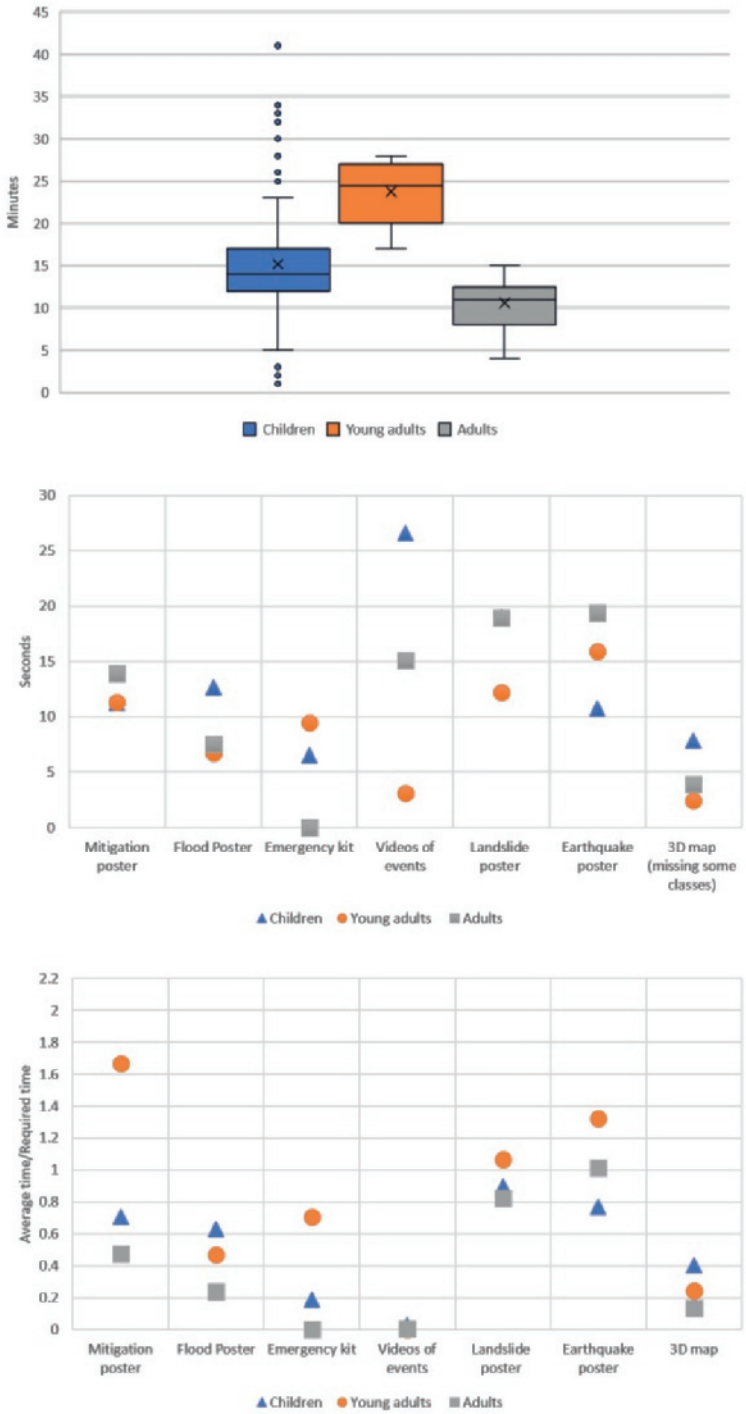


Figure 6.7: Time and tracking variable for each exhibit of the Romanian 'Alerte" exhibition. Top: Time spent in the room (children n=205, young adults n=8, adults=17), middle: average holding time and, bottom: holding power.

As shown by holding power values lower than one (Figure 6.7, bottom graph), Romanian children did not spend enough time at each of the exhibit to fully visit them. For this age group, the exhibits presenting the highest holding power are the posters. This result is also valid for the adults and partially for the young adults. For the latter, the holding power of the emergency kit was higher than for the two other age groups. Moreover, posters were visited longer than the required time by the young adults except for the one on floods. For adults, the poster related to earthquake hazards was visited for the time required to fully appreciate it – all assuming they did not just get stuck in a traffic jam. The posters presenting information on landslides, floods and mitigation measures were visited less than required, especially the two last mentioned.

6.3.2 Satisfaction Survey

The visitors highly appreciated the exhibitions. More than 84% of visitors of each group gave a score of 4 or 5 on a 5-points Likert scale, to the question whether they liked the exhibition (Figure 6.8). This is true for both countries, except for the French teenagers, for which this percentage was lower (61%). The presentation of the content seemed to be appropriate for most of the French and Romanian teenagers and adults as 60% to 85% scored this 4 or 5 on a 5-points Likert scale (Figure 6.9).

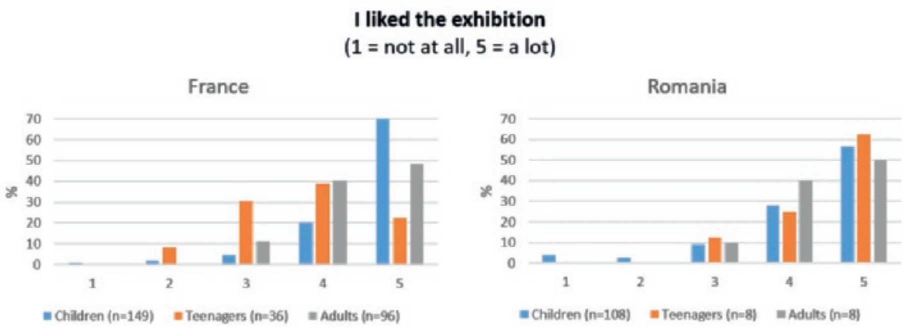


Figure 6.8: Answers to the statement "I liked the exhibition" in percentages of possible answers 1 = not at all to 5 = a lot. In France, 149 children, 36 teenagers and 96 adults answered (one child, one teenager and six adults did not answer to this statement). In Romania, 108 children, 8 teenagers and 8 adults answered to this statement while 2 children did not.

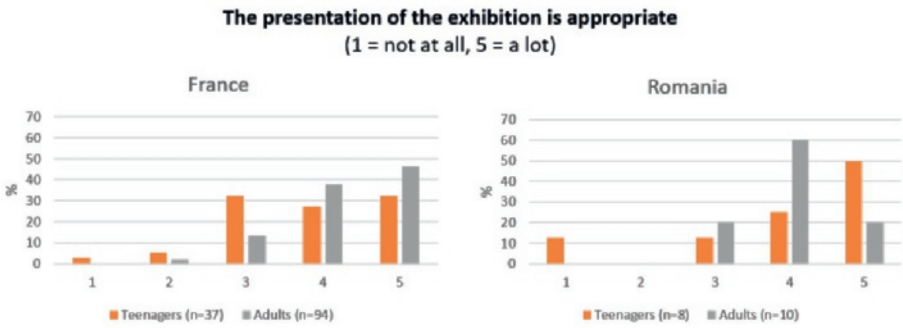


Figure 6.9: Answers to the statement "The presentation of the exhibition is appropriate" in percentages of possible answers 1 = not at all to 5 = a lot. In France, 37 teenagers and 94 adults answered (eight adults did not answer to this statement. In Romania, 8 teenagers and 10 adults answered.

In France, the top-3 most liked exhibits by the children are the flood scale model, the seismograph and the video of events (Figure 6.10). Although generally the teenagers gave lower scores for all the exhibits, these three interactive exhibits are also the ones they liked most. The adults appreciated all exhibits as more than 50% of the adults gave a score of 4 or 5. The top-3 of this group is slightly different: along with the video of events, they liked the videos of testimonies (watched individually on tablets) and the posters on emergency guidelines most. In Romania, it is difficult to identify which exhibits were liked the most as the answers are generally very high and do not differ a lot, as well as the number of respondents in the category young adults and adults was low. It is nevertheless possible to see that the emergency kit was the least appreciated exhibit.

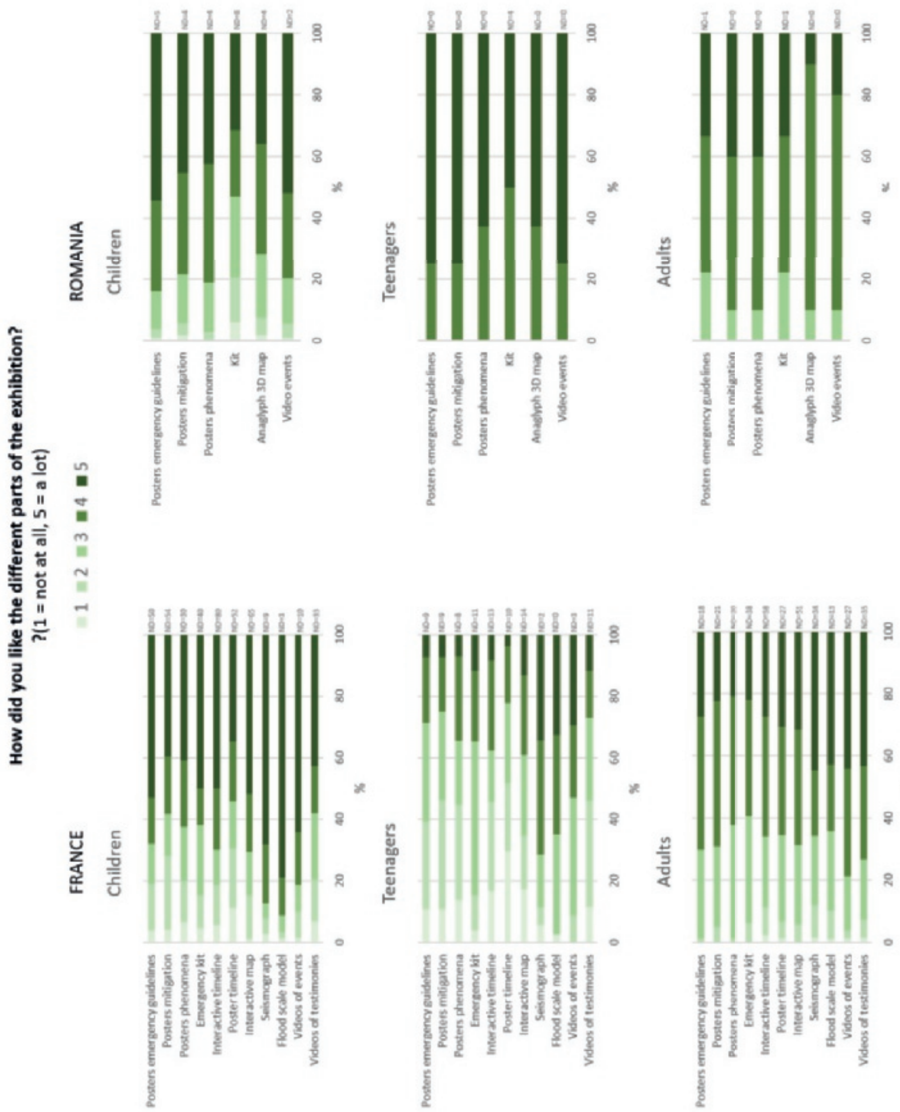


Figure 6.10: Answers of the French and Romanian visitors to the question: "How did you like the different parts of the exhibition?". Respectively n=150 and n=110 children; n=37 and n=10 teenagers; n=102 and n=10 adults. The numbers of visitors that did not answer are given for each exhibits by ND=xx.

In France, it is difficult to see a distinct trend in the way the exhibition changed the views of the visitors on natural hazards and associated risk, as reported by the visitors themselves (Figure 6.11). In Romania, it appears that the exhibition changed the views of children and young adults as more than 60% gave a score of 4 or 5 on the 5-points Likert scale on this question. These results are similar to those related to the surprise that the exhibition caused (Figure 6.12).

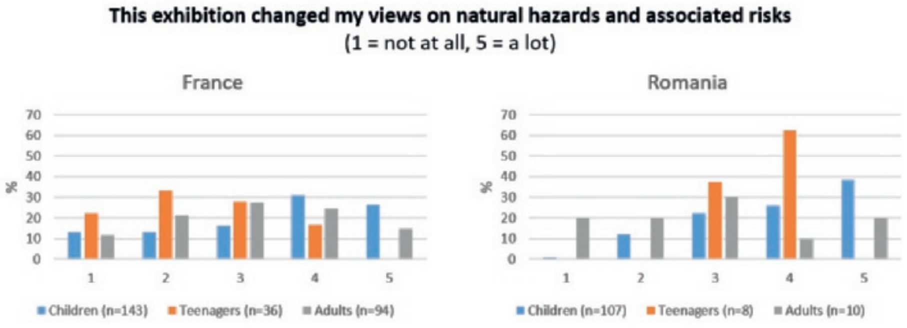


Figure 6.11: Answers to the statement "This exhibition changed my views on natural hazards and associated risks" in percentages of possible answers 1 = not at all to 5 = a lot. In France, 143 children, 36 teenagers and 94 adults answered (seven children, one teenager and eight adults did not answer to this statement). In Romania, 107 children, 8 teenagers and 10 adults answered (three children did not answer to this statement).

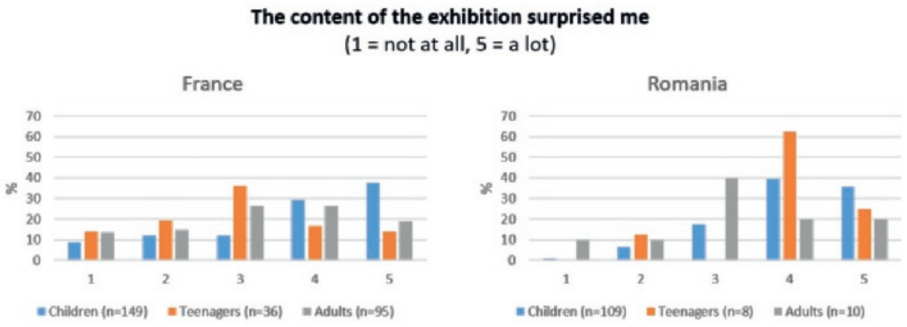


Figure 6.12: Answers to the statement "The content of the exhibition surprised me" in percentages of possible answers 1 = not at all to 5 = a lot. In France, 149 children, 36 teenagers and 95 adults answered (one child, one teenager and seven adults did not answer to this statement). In Romania, 109 children, 8 teenagers and 10 adults answered (one child did not answer to this statement).

The exhibition appears to have been perceived educative as more than 60% of the French and Romanian children and the French adults gave a score of 4 or 5 (Figure 6.13). On the contrary, most of the Romanian adults have not learned a lot, 60 % attributing a 2 on the 5-points Likert scale. This may be explained by the fact that all Romanian adults were professionals. In both France and Romania, most teenagers and young adults gave a score in the middle of the 5-points Likert scale, showing they were undecided on this aspect.

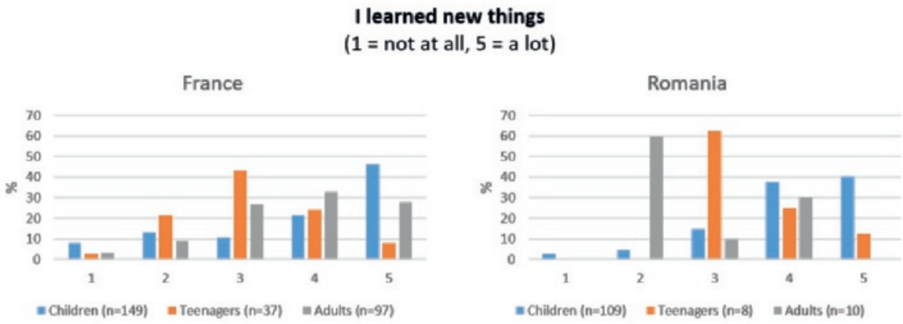


Figure 6.13: Answers to the statement "I learned new things" in percentages of possible answers 1 = not at all to 5 = a lot. In France, 149 children, 37 teenagers and 97 adults answered (one child and five adults did not answer to this statement). In Romania, 109 children, 8 teenagers and 10 adults answered (one child did not answer to this statement).

6.4 DISCUSSION

Timing and tracking using RFID technology showed that visitors from different age groups did not behave similarly at the French exhibition. On average, children visited the exhibition quickly and shared their time equally between both rooms. Teenagers and the adults, on the other hand, took their time in the first room and then finished the exhibition rather quickly. This suggests that it is preferable to place the most important information at the beginning of the exhibition, and include very attractive exhibits (e.g. the digital tablets) further on, to keep attention when visitors get tired. The position of the important message on individual exhibits also requires some thought. The rather low holding times and holding power values observed at both the French and the Romanian exhibitions suggest that the key information should be quickly accessible.

It is not a novel finding that interactive and dynamic exhibits have greater attraction and holding powers (Shettel, 1973 and Screven, 1975 in Boisvert & Slez, 1995; Koran et al., 1986 and Koran et al., 1984 in Sandifer, 2003). However, in the French 'Alerte' exhibition, the interactive and dynamic exhibits were more attractive for the children and teenagers only and not for the adults. This is especially true for the seismograph, the only exhibit with which the body interacts (jumping to create an earthquake). This type of exhibits has proven to be very attractive for the youngest (Hornecker, E., & Stifter, M., 2006). Nevertheless, in both exhibitions the holding time of interactive and dynamic exhibits was generally not higher for any of the age groups. The only exceptions are the tablets in the French exhibition for the adults, and the videos in the Romanian exhibition for children. Similarly, the holding power of the videos was very low but this can be explained by the long time required to view them entirely. Interestingly, there may be cultural differences in the holding time and power of static exhibits. This is suggested by the much higher holding power of posters for Romanian children and young adults than for the French children and teenagers.

Another example of the fact that attraction power and holding time and power do not go hand in hand can be seen in the French case. For that version of the 'Alerte' exhibition there are large differences in the number of adults being tracked near a poster. While the values are high for the one on floods, the poster on mitigation measures was visited by far fewer people. However, the average holding times and holding power are comparable. This means that on average the adults stopping at the mitigation poster stayed there longer than at the other poster. It is difficult to explain whether this is due to the location of the posters or to the difference in content. The satisfaction survey gives no hints as the results for both posters are similar (Figure 6.10).

Methodologically, the differences between the timing and tracking measures originating from the RFID data shows that they are not interchangeable. Hence, based on one of them only, one cannot draw conclusions on the type of exhibits that is more useful or effective for increasing awareness. Moreover, there is a need for complementary information, e.g. from direct observation, to reach decisive conclusions. From what could be observed at the exhibitions, RFID-technology seems to be more useful for the attraction power than for the holding time in our 'Alerte' exhibitions. While the RFID results related to attractiveness correspond to our experience, the results concerning holding time are not always reliable, as the behavior of French children in front of the seismograph showed. They often took a long run-up to jump in front of the seismograph as well as waited for their turn to play with the exhibits, temporarily going out of the measuring range of the antenna for longer than 30 seconds. This artificially increased the number of times they were recorded by the antenna and induced an underestimation of the average holding time. In addition, the fact that a visitor could pass an antenna for 1-2 seconds when walking most likely resulted in an underestimated average holding time. In this light, this variable is less informative. Similarly, from our observation log books, we know that the absolute time spent at the exhibition as a whole is underestimated by a few minutes.

To a lesser extent, holding power values can also be debated. While they can help to compare the behavior of different types of visitors at a given exhibit, it seems more difficult to get insights for the comparison between exhibits which require very different duration of visits. As an example, the very low holding power of the videos could be wrongly interpreted as negative. We set the entire duration of the videos somewhat arbitrarily as the minimum time required to get the message of this exhibit. However, there was redundancy in the testimonies and shooting of events in terms of the general awareness raising message. Therefore, the people watching these videos could get the general message after only watching for example two or three testimonies instead of all 15 available testimonies. A sensitivity analysis on the French data (figure 6.14) shows that the holding power of the videos of testimonies is comparable to the holding power of the other exhibits if we use as the time required to "visit" the videos the time it takes to watch two or three testimonies.

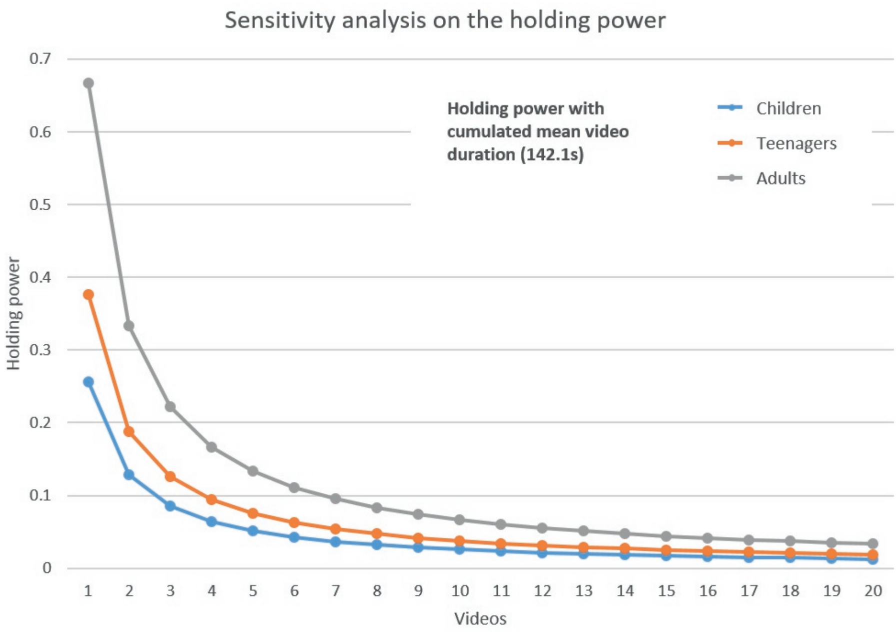


Figure 6.14: Sensitivity analysis on the holding power for the testimonies' videos presented on the digital tablets at the French 'Alerte' exhibition.

Even given these limitations, RFID-technology is worth using as it is quantitative and a relatively low-labor timing and tracking technology that can complement direct observation and video recording. This is especially the case in large exhibitions with large groups of visitors. In small exhibitions, such as in Romania (and probably in extremely busy large exhibitions), the results are not very reliable as traffic jams may occur, resulting in overestimated results.

The satisfaction of the visitors and the fact that most of them found that the presentation of the content was appropriate, are positive results. It means that some of the preconditions for the exhibitions to be effective were fulfilled. In fact, how an awareness raising effort is perceived and understood are important factors determining its effectiveness (e.g. Rohrmann, 1998; Lellig et al., 2014). Similarly, surprise, learning, and change in opinions are part of awareness raising effectiveness. Concerning those aspects, our results differ more. The exhibitions were not effective in those terms for some of the visitors, especially for adults and for teenagers. In some case this is not surprising. The Romanian adults were professionally involved in natural hazard and related risks management, so it is not unexpected that they did not learn a lot. However, most children learned a lot from these exhibitions. Awareness raising for them is important because they are often considered as more vulnerable, physically and psychologically, to disasters caused by natural hazards, as well as conveyors of disaster prevention through the society (Johnson, 2014 for a literature review on those topics).

Combining RFID technology with a satisfaction survey results in information on both visitors' behavior and visitors' perception as well as in a better assessment of effectiveness than with one of these methods on their own. Partly they can confirm each other, e.g. with respect to the most preferred and attractive exhibits for the children. Along, with the fact that most children learned new things visiting the exhibition, this suggests that the more an exhibit is interactive, the more acquisition of knowledge is important (Shettel, 1973 and Screven, 1975 in Boisvert & Slez, 1995) for this group age.

6.5 CONCLUDING REMARKS

This study showed the potential of RFID technique to time and track visitors in exhibitions. RFID raw data are, however, too voluminous to be used directly. They need to be filtered and processed to derive timing and tracking measures such as attraction power, holding time and holding power. The RFID results suggested that important messages to be conveyed should be placed at the beginning of an exhibition and to use attractive exhibits further down to keep attention. Although, dynamic exhibits such as videos or objects seemed to be more attractive, they do not always retain the attention of the visitors longer than static ones. Moreover, the study gave some hints that there may be cultural difference in the preferences of visitors. Therefore, it seems that one must not bet on interactivity only to disseminate risk related information to the general public.

RFID proved to be a powerful technique, in particular in large exhibitions and which can be used while complying with strict privacy regulations as the RFID tags are anonymous. However, it is not a suitable approach for small crowded set-ups where people are not able to move freely. Moreover, derivative variables, and especially the holding power, strongly depend on the choices made to set the minimum reading time. This, however, is independent of the surveying technique used, with the difference that e.g. video surveying could allow visual validation with a small number of visitors.

As set in this study, RFID and survey results cannot be compared directly. However, we demonstrated the importance of operationalizing in combination various methods in order to evaluate the potential of different exhibits to convey an awareness raising message. While RFID provides quantitative results, a survey is able to give information on opinions that are as much as valuable in the context of identifying effective risk communication efforts.

6.6 REFERENCES

Austin, E. W., & Pinkleton, B. E. (2015). Strategic Public Relations Management: Planning and Managing Effective Communication Campaigns (Vol. 10). Routledge. Page 57. Livre 389

Bannon, L., Benford, S., Bowers, J., & Heath, C. (2005). Hybrid design creates innovative museum experiences. Communications of the ACM, 48(3), 62-65.

Boisvert, D. L., & Slez, B. J. (1995). The relationship between exhibit characteristics and learning-associated behaviors in a science museum discovery space. Science education, 79(5), 503-518.

Bollo, A., & Dal Pozzolo, L. (2005, July). Analysis of visitor behaviour inside the museum: An empirical study. In Proceedings of the 8th International Conference on Arts and Cultural Management, Montreal (Vol. 2).

Hornecker, E., & Stifter, M. (2006, November). Learning from interactive museum installations about interaction design for public settings. In Proceedings of the 18th Australia conference on Computer-Human Interaction: Design: Activities, Artefacts and Environments (pp. 135-142). ACM

Hsi, S., & Fait, H. (2005). RFID enhances visitors' museum experience at the Exploratorium. Communications of the ACM, 48(9), 60-65.

Johnson, V. A. (2014). Evaluating disaster education programs for children: a thesis presented for the degree of Doctor of Philosophy in Emergency Management at Massey University, Wellington, New Zealand (Doctoral dissertation, Massey University).

Kanda, T., Shiomi, M., Perrin, L., Nomura, T., Ishiguro, H., & Hagita, N. (2007, April). Analysis of people trajectories with ubiquitous sensors in a science museum. In Proceedings 2007 IEEE International Conference on Robotics and Automation (pp. 4846-4853). IEEE.

Koran, J.J. Jr., Koran, M.L., & Longino, S.J. (1986). The relationship of age, sex, attention, and holding power with two types of science exhibits. Curator, 29, 227–235.

Koran, J.J. Jr., Morrison, L., Lehman, J.R., Koran, M.L., & Gandara, L. (1984). Attention and curiosity in museums. Journal of Research in Science Teaching, 21, 357–363.

Klein, H. J. (1993). Tracking visitor circulation in museum settings. Environment and Behavior, 25(6), 782-800.

Lellig C., Graf, O., and Moser S. (2014) Communication pour une protection efficace des bâtiments. Rapport final concernant la 7e mise au concours de la Fondation de prévention des établissements cantonaux d’assurance ECA, Berne, 128 pages.

Modsching, M., Kramer, R., Hagen, K. T., & Gretzel, U. (2008). Using location-based tracking data to analyze the movements of city tourists. Information Technology & Tourism, 10(1), 31-42.

Mohandes, M. (2010). A Case Study of an RFID-based System for Pilgrims Identification and Tracking. INTECH Open Access Publisher.

Rohrmann, B. (1998). Assessing hazard information/communication programs. Australian Psychologist, 33(2), 105-112.

Sandifer, C. (2003). Technological novelty and open-endedness: Two characteristics of interactive exhibits that contribute to the holding of visitor attention in a science museum. Journal of research in science teaching, 40(2), 121-137.

Screven, C. (1975) The effectiveness of guidance devices on visitor learning. Curator, 18, 219-248.

Shettel, H.H. (1973) Exhibits: Art form or educational medium. Museum News, 52, 32-41.

Shettel, H. H. (1997). Time—is it really of the essence?. Curator: The Museum Journal, 40(4), 246-249.

Solic, P., Rozic, N., & Marinovic, S. (2009, June). RFID-based visitors modeling for galleries using Markov model. In Telecommunications, 2009. ConTEL 2009. 10th International Conference on (pp. 105-110). IEEE.

Wu, D. L., Ng, W. W., Yeung, D. S., & Ding, H. L. (2009, July). A brief survey on current RFID applications. In 2009 International Conference on Machine Learning and Cybernetics (Vol. 4, pp. 2330-2335). IEEE.

Yalowitz, S. S., & Bronnenkant, K. (2009). Timing and tracking: Unlocking visitor behavior. Visitor Studies, 12(1), 47-64.

Zhu, X., Mukhopadhyay, S. K., & Kurata, H. (2012). A review of RFID technology and its managerial applications in different industries. Journal of Engineering and Technology Management, 29(1), 152-167.

7. Synthesis: Considerations on natural hazard risk communication and assessing its effectiveness

This last chapter synthesizes this doctoral thesis. First, the research questions presented in Chapter 1 are answered (section 7.1). The chapter concludes with a discussion of biases and limitations of this work (section 7.2), personal observations on the role of the researcher (section 7.3) and perspectives for further work (section 7.4).

7.1 RESEARCH ON VISUAL RISK COMMUNICATION AND THE EVALUATION OF ITS EFFECTIVENESS

In the last decades, the importance of risk communication for disaster risk reduction has been acknowledged (Chapter 1). Knowing and understanding the risk is considered a prerequisite for undertaking meaningful and useful actions. Risk communication can take many forms, and often the use of visuals is considered very appropriate. Thus, it is important to increase insight in the effectiveness of risk communication efforts using visuals that aim at increasing public risk awareness of natural hazards. To this end, this thesis has addressed the following research questions:

- How are risks related to natural hazards currently communicated?
- How are these communication efforts currently evaluated?
- Can a real-life risk communication effort using visuals increase risk awareness of natural hazards?
- How attractive are different visuals at an exhibition for different groups of visitors?

Concerning the first question, chapter 2 showed that most visual risk communication related to natural hazards currently concentrates on floods. Although the information content of these efforts is diverse, the main goals are usually to inform and warn the general public and thus improve risk prevention and preparedness. The messages are mostly to warn the public and inform them of the level of danger and are not connected to the response and recovery phases of risk management. Various types of visuals are used to communicate these messages, but maps appear to be the most used type of visual. Thus, there is still some space to further develop visual risk communication in other phases of risk management and using other types of visuals.

Chapter 3 focuses in more detail on one particular means of risk communication using visuals: smartphone applications disseminating avalanche danger related information. Interviews with the developers showed that the avalanche risk managers' community is well advanced in its thinking on what is the most important information concerning the risk of avalanches. The message, centered on the avalanche danger situation, is almost uniform for all apps or at least it uses the same concept. This is due to a long history of exchanges in the community on how to communicate the avalanche risks, and to the development of a common avalanche danger scale. Currently, the debate is mostly focused on how to disseminate the information and in particular how to visualize it. Although there are some similarities in most apps, the observed differences show that there is still no consensus on the best way to use visual communication to inform on risks related to avalanches.

As many visual risk communication efforts related to natural hazards are developed, it is interesting to gain more understanding on how their effectiveness is evaluated (question 2). Chapter 2 showed that their effectiveness is rarely evaluated and when it is, mostly the process is evaluated, e.g. the appropriateness in relation to the users' requirements or the users' ability to understand the content. Output evaluations that assess the impact on risk knowledge, awareness, perception, attitudes, beliefs or behavior are published sporadically in academic journals.

Chapter 3 showed that there is a link between what the designers of avalanche risk apps perceive as good practices and how they actually design these apps. The developers admit that they do not know whether their choices are effective, and they see an urgent need for evaluation. Unfortunately, lack of resources and expertise are hindering them to really evaluate the effectiveness of their apps. The app developers believe this is where scientists can play an important role to inform and contribute to the practice. Scientists could be the resources that the developers need and could take the time to evaluate the apps, not only in terms of appropriateness, understanding, and perceived usefulness, but also in terms of changes in behavior, decision-making and ultimately the number of accidents. Moreover, studying the impacts of visual risk communication related to avalanches could be the start of studying the impacts in relation to other natural hazards and risks as well. Since avalanches are affecting rather well-defined areas of our planet and the community of risk communicators is relatively small and tight, it seems a good hazard to start research on both risk communication's impacts and the methodology to assess these impacts.

Although the academic literature on the effectiveness of risk communication related to natural hazards is limited, this does not mean that risk communication is not evaluated at all. It is understandable that organizations evaluating their own risk communication efforts do not disseminate the results if these reveal for example improper use of resources or lack of impact. It is more surprising that scientists, particularly those studying natural hazards, are reluctant to explore this field. This is not necessarily due to the lack of interest in communication. Outreach activities and awareness raising efforts by scientists are manifold. For example, the number of blogs on natural hazards written by scientists is increasing and this is even encouraged as activities to undertake for a young scientist to develop their skills. Moreover, academic organizations are strongly promoting science communication. For example, at the major geosciences conferences, such as the American Geophysical Union Fall Meeting (AGU) and the European Geosciences Union General Assembly (EGU), the number of sessions dedicated to communication has greatly increased in the last years as analyzed from the information provided on the meetings portals. Similarly, the Geological Society of America wrote a position statement on the need for geoscientists to communicate effectively to increase hazards awareness , and Horizon 2020, the European Framework Programme for Research and Innovation, distributed a communication guidance document . Nevertheless, judged by the number of abstracts linked to these topics presented at the AGU and EGU meetings in the last years, communication on natural hazards and climate change is not extensively studied and evaluated (Figure 7.1).

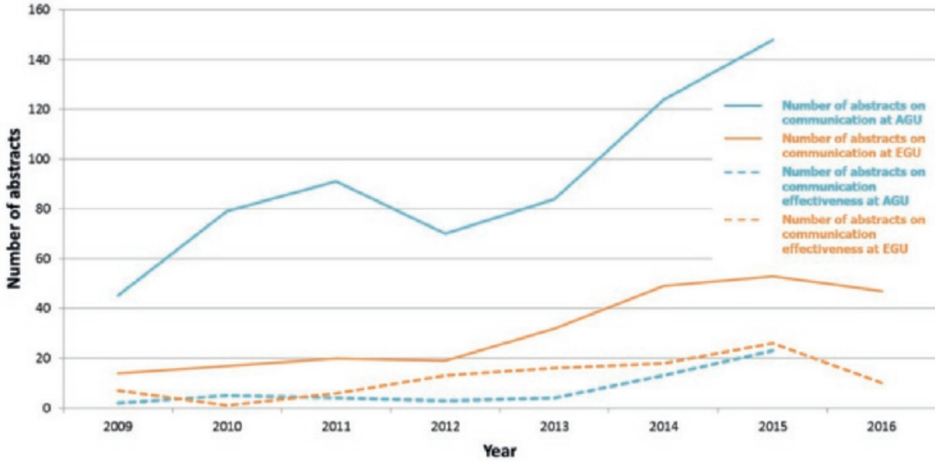


Figure 7.1: Number of abstracts presented at AGU and EGU meetings related to communication and its effectiveness in the fields of natural hazards and climate change. The abstracts were identified on the EGU and AGU meetings portals using the key words 'communication' and 'dissemination'. The total number of accepted abstracts ranged between 16,000 and 20,000 per year for the AGU and 12,000 and 16,000 per year for the EGU during this period.

Although the number of communication related abstracts in the two largest geoscience conferences is increasing over the years, the number of abstracts related to the evaluation of communication remains very low. This is quite surprising as the evaluation of communication efforts is considered a separate step in any communication process and the scientific literature on natural hazards related communication recognizes the need for this step (see Chapters 1 and 2). Evaluation is essential for finding out whether risk communication was effective or needs to be improved. Evaluation is also a way to increase legitimacy, credibility, consistency, transparency and accountability. These are important in the process of creating trust, which is a necessary prior condition for effective communication. In addition, risk communication practitioners themselves express the need to evaluate risk communication, as shown in chapter 3.

Having shown the importance and the limited practice of evaluating the effectiveness of risk communication on natural hazards, it is now opportune to turn to the third research question: Can a real-life risk communication effort using visuals increase risk awareness of natural hazards? In order to answer this question, it was necessary to develop a real-life risk communication effort. Chapter 4 describes how, the 'Alerte' exhbition was developed in the Ubaye valley in France with the help of the local community. It quickly became evident that action-oriented research was an appropriate approach in this case. Involving the stakeholders was mandatory for setting up research that would not only be scientifically interesting, but also meaningful for society. In such a relatively small and isolated community, reaching out to the people is facilitated if researchers pair with locals. Generally, action-oriented research appears to be well adapted for disaster risk reduction research and applications. For such important matters, ethics imposes the participation of local stakeholders. This principle is widely accepted as community-based risk management is clearly advocated by Disaster Risk Reduction governance and practice. In this research, the type of communication effort, i.e. an exhibition, was chosen by the stakeholders and not the researcher. The local stakeholders also participated in several steps of the study, including research design, data collection and dissemination.

The action-oriented approach used in the study was meaningful for the local stakeholders but not devoid of constraints. It required a significant amount of time as well as of adaptability in the research plan and questions. Moreover, generalizing the results of such an action-oriented approach adapted to a specific disaster risk reduction case is difficult as they depend on varying aspects, such as the physical, cultural, socio-economical and emotional contexts. Furthermore, in action-oriented research the development of the research process is at least as important as the results. These constraints are not very compatible with the current academic world, which has become increasingly dependent on project funding with strict rules and constraints, and where fast and numerous publications, preferably with clear positive results, are encouraged, hindering long-lasting, longitudinal studies. For action research, researchers' personal and institutional agendas, schedules and goals should be flexible enough.

The effectiveness of the "Alerte" exhibition was assessed using a pre-test/ post-test research design using a questionnaire-based survey (Chapter 5). The exhibition presented the natural hazards occurring in the region and their effects. For a small town in the French Alps and in the short term, the exhibition proved to increase risk awareness. However, the exhibition did not have the same impact on all the factors in the framework for measuring awareness that was adopted for this research. Factors independent of a specific natural hazard were more affected by the visit of the exhibition. They were mostly linked to preparedness (i.e. "feeling of being prepared" and "feeling of having all the knowledge and information to respond"), but also to the perception of vulnerability. The perception of the consequences of specific natural hazards increased especially for children and teenagers. Risk awareness particularly increased for hazards that they had not experienced, in this case floods. This supports the idea that risk awareness is influenced by previous experience as well as education, and suggests that risk communication can overcome a lack of experience and education.

These results can inform future risk communication efforts. For example, while multi-hazard communication may suit the needs of teenagers and children, efforts focusing on only one hazard would probably be more appropriate for adults. The younger generations' variations of the awareness of risks linked to a specific hazard is not affected by the fact that several natural hazards were presented in the exhibition at the same time. Moreover, even though the increase in awareness was bigger for visitors that had little education on natural hazards and had not experienced them, some effects could still be observed for those that considered themselves already aware of these hazards and that had experienced them. Therefore, one could envisage a continuous repetition of risk communication efforts with an alternating focus on the different natural hazards. For children and teenagers that have a lower chance of having experienced natural hazards, risk education could be strengthened in the school curricula, especially in areas experiencing a high risk of natural hazards, such as the Ubaye Valley.

Coming back to the use of visuals in risk communication efforts related to natural hazards, one last research question has been formulated at the beginning of this doctoral thesis: how attractive are different visuals at an exhibition for different groups of visitors? In the 'Alerte' exhibition, various communication tools were used (Chapter 6). Two methods were used to assess the relative attractiveness of the different tools: Radio Frequency Identification (RFID) and a satisfaction survey. These two methods have both advantages and disadvantages and can complement each other.

The RFID technique is particularly powerful in monitoring visitors' paths. Moreover, unlike video-based observational methods, the privacy of the people whose displacements are monitored can be respected. RFID allows to calculate timing and tracking measures, such as how much the visitors are attracted by the different exhibits and how long they stay next to them, and compare this with the estimated time needed to fully grasp the conveyed messages. Results can be useful to provide guidelines on where to place the important messages and the various types of exhibits in an exhibition space. It appeared that it could be more effective to arrange important information at the beginning of the exhibition while the attractive dynamic exhibits could be located at the end in order to keep the attention of the visitors for the whole visit. However, one should not assume that dynamic exhibits are always more effective than static ones: sometimes more static exhibits retained the attention of the visitors as much. To calculate time and tracking measures, it is necessary to filter and process the raw RFID data quite extensively, and the derived variables depend on the choices made. Furthermore, as demonstrated in this research, RFID is not well adapted to track visitors' path in small crowded spaces.

The results of the satisfaction survey confirm the RFID results as the declared preferred exhibits are those that were the most attractive according to the RFID data. The satisfaction survey moreover indicate that the content of the 'Alerte' exhibition was highly appreciated and perceived as appropriate. These are preconditions for effectiveness of conveying messages aiming at raising risk awareness. Furthermore, the learning potential of the exhibition for the children appeared to be long-lasting. This confirms the result of the pre-test/post-test research design that this type of risk communication effort can overcome lack of education.

7.2 SOME BIASES IN TESTING THE EFFECTIVENESS OF A REAL COMMUNICATION EFFORT

The results of the evaluation of the 'Alerte' exhibition in terms of raising awareness of natural hazards of the general public is subject to several biases. This is due to the choice of conception and measurement frameworks, data gathering techniques and statistical analysis choices.

In addition to the constraints previously mentioned of adopting the action-oriented framework proposed by Small and Uttal (2005; Chapter 4), this approach also introduced biases in the results. For example, some segments of the general public were left out, e.g. tourists or working adults, as the relevant stakeholders were not in favor of including tourists and the schedules of the venue could not accommodate the availability of working adults. Therefore, the results do not contain information on these particular sub-categories of the general public. The use of action-oriented research also had an impact on the results related to the sub-categories of the general public that were included in the research. By complying with the need to include stakeholders as much as possible, the characteristics of the sample were more or less imposed. For example, it would have been inopportune to bypass stakeholders in order to increase the size of the sample. The results based on the statistical analysis should be considered without losing sight of the fact that they are very sensitive to samples' sizes.

The results are also influenced by the way the data was gathered and analyzed. Answers to survey questions using a 10-points Likert scale can be analyzed using different statistical method used, and the method used affects the results. In any statistical analysis assumptions are made, and this should be considered when decisions are made on the basis of such results.

In addition, it is difficult to combine further the results of the pre-test/post-test research design on the one hand, and the RFID technique and the satisfaction survey on the other. The research setting does not allow to isolate the impacts of the content and of the form of risk communication on risk awareness. Nevertheless, each of the three methods used was useful. Unlike in a laboratory-setting, where each parameter is controlled, in field research it is very difficult to isolate the exact causes of the effect of a real-life communication effort. Consequently, it is advisable to use several perspectives or angles to try and understand the effectiveness. Combining the results of several methods results in a fuller picture of how a real-life risk communication effort can increase risk awareness of a community.

Limitations arise also from the risk awareness measurement framework that was used (Enders, 2001; Chapter 5). It conceives risk awareness in a specific way that is subject to discussion. Its use opens the discussion on how to operationalize the measurement of risk awareness. Looking at the literature, it appears that this complex cognitive construct is rarely defined and when it is, the definition is not precise enough to be translated into one or several indicators. Often, risk awareness refers only to a kind of knowledge. Enders' framework includes not only factors that are linked to knowledge, but also factors related to risk perception and preparedness. Although this could be disputed, as such it is believed to reflect well the different kinds of impacts that risk communication can have on people.

The major issue with case-study research as conducted for this thesis is generalization. We believe that some of our results can be extended to other areas that are similar (e.g. other small communities in mountainous area), at least hypothetically, as best guesses. For example, our results could help to prioritize risk communication efforts and risk communication research. Building up theory, requires more case studies.

7.3 PERSONAL REFLECTIONS ON DOING RESEARCH IN-BETWEEN SOCIAL SCIENCES AND GEOSCIENCES

It would be incorrect to say that stress and tension with academic schedules did not occur in the timely process of this research. However, as the action-oriented approach was not framed at the beginning of the process, but rather evolved, the constraints were not anticipated but accepted as an inevitable effect of choosing this approach. The fact that I understand the French culture, as it is mine, helped me to perceive that no other approach could be adopted in the Ubaye Valley. This helped me accept its side-effects.

The difficulty of generalizing the results of my research does not bother me much. The important thing is that they were useful at the local level. Not only did the research project highlight the need for risk communication in the Ubaye valley and provide guidelines for further efforts, it also triggered discussions between the inhabitants and pointed out the potential of local collaboration and their benefits for disaster risk reduction. This is in fact a general conclusion. Furthermore, it was a perfect project to learn how to work with stakeholders and therefore a very good training for my current career as a DRR practitioner, which also involves interaction with local stakeholders and popularization of science related to natural hazards. It allowed me to add to my geoscientist background skills in social sciences, which I will be able to use in other settings as well.

Interdisciplinarity was both advantageous and disadvantageous at several levels in this research project. Since disaster risk reduction involves reducing the negative effects of natural phenomena on society, interdisciplinarity is key. However, boundaries between the traditional scientific fields are still rather closed and it can be difficult to move across them. In some cases, being a geoscientist doing social sciences appeared to be an advantage in relationships with scientists working in 'harder' fields. My understanding of the physics of natural hazards was seen as proof of my ability for doing this study. On the other hand, this background was perceived as negative by some social scientists that I met as I lacked experience to strictly frame the research according to their particular social sciences principles.

The geoscientists involved in the project accepted a more intuitive or experimental approach at the beginning of the research. This acceptance was nevertheless counterbalanced by a strong request to produce quantitative results and statistical analysis. The choice of the appropriate statistical methods was not as easy as it may seem. Here again, there are many views and debates between the different scientific disciplines on how to approach this. In this research, it took much time to judge, with a scientific conscience, the appropriateness of a given statistical test. Still, none of the quantitative methods that were used to assess the effectiveness of the 'Alerte' exhibition were able to capture some very interesting impacts that could be observed, such as the interaction between the inhabitants that were triggered by the exhibition. Following the viewing of one of the testimonies presented in the exhibition, one teacher organized a meeting between the children and the elderly person that had given the testimony to go deeper into the topic of his flooding experience. Moreover, some of the pupils were brought to the hospital to talk about natural hazards with patients. Furthermore, during the discussions that took place at the time of the second post-test, children proved to have a very good memory about the content that was presented at the exhibition. They also showed much enthusiasm to be asked again about this event and the topic of natural hazards in general. These impacts are more difficult to grasp using a quantitative approach than a qualitative one. Consequently, it is reasonable to say that a qualitative approach could have been included as well in the research design for this case study on risk communication effectiveness.

7.4 PERSPECTIVES

Although this research contributed to a better understanding of the effectiveness of risk communication related to natural hazards, it also highlights several directions for further work.

Related to the methods and approaches that were used in this thesis, several aspects can be further developed. For example, although the importance of increasing risk awareness is not debated, there is certainly a need to further study the factors that contribute to it and how these can be operationalized and measured, both in terms of indicators and research design. This should be done for various natural hazards and in multiple cultural and social settings. If quantitative approaches are chosen for this endeavor, then more work in terms of the statistical analysis would help to identify how changes in risk awareness can be best analyzed. Mixed qualitative-quantitative approaches can also be considered.

Moreover, there is room for many more studies on the use of Radio-Frequency identification for monitoring movements of the visitors in exhibition settings. This technique has a clear potential for improving the understanding of the attractiveness of different types of exhibits, their capacity to retain attention and, by extension, their power of conveying information and triggering learning. This is particularly interesting for exhibitions or museums that aim to teach or change attitudes and beliefs.

This thesis has shown that some risk communication practitioners would be keen users of further studies on the effectiveness of the efforts that they are designing. This is a great opportunity for scientists to seize. Here there is a direct and quick possibility to increase the social impact of research and help communities throughout the world to be more resilient to natural disasters.

There is a lack of longitudinal studies that investigate the long-term effects of risk communication efforts. It would be very interesting, informative and rewarding to return to the Ubaye Valley and assess another time the effect of the 'Alerte' exhibition on the risk awareness of the inhabitants.

Every year, many communities are affected by natural hazards and significant losses take place in terms of victims, goods and assets. Many disasters could be avoided if the right protective behaviors were taken. The ultimate objective of risk communication research should be to study which ways are most effective in stimulating appropriate action by people that are potentially affected by natural hazards or in charge of risk management.

8. Annexes

8.1 ANNEX A1: ADDITIONAL INFORMATION ON THE SMARTPHONE APPLICATIONS FOR COMMUNICATING AVALANCHE RISK INFORMATION PRESENTED IN CHAPTER 3

Table A1.1: Additional information gathered on the smartphone applications, either through the interviews or by using the apps during the winter season 2014-2015. The apps are referred to with an ID Number: 1. Avalanche Canada, 2. Utah Avalanche Center, 3. Avalanche Forecast, 4. White Risk, 5. Varsom and 6. SnowSafe.

INFORMATION	OPTIONS	APPS ID NUMBER
Validity period of the bulletin	Explicit time span	1
	Time to the next bulletin	4, 5
	No (Issuing time of the current bulletin)	2, 3, 6
Spatial coverage	Whole country (in practice only the Alps)	4
	Most exposed and vulnerable regions	1, 5
	Most exposed and vulnerable regions + by mountain ranges	2
	Several zones of different countries	6 (full Austria, Bavaria and Slovakian mountains), 3 (Canadian and American Rockies)
Terminology for elevation range	“under/above the limit of the forest”	6
	“below treeline, treeline, alpine”	1
	Flexible elevation range according to avalanche problem type (e.g. wind slabs over 500 m.a.s.l)	5
	By avalanche prone area (e.g. approximately above 2200m)	4
Additional visual means	Interactive tabs for risk management tools and knowledge content	4
	Access to traffic pictures	2
	Upload of pictures from users possible	1
Possible feedback	Date, time, location, skiing conditions (amazing, good, ok or terrible), snow conditions (crusty, deep powder, hard, heavy, powder, wet or wind affected), type of riding slopes (alpine slopes, convex slopes, cut-blocks, dense trees, mellow slopes, open trees, steep slopes or sunny slopes), types of slopes that were avoided (same options than the previous point minus dense trees and mellow slopes), weather conditions (cloudy, cold, foggy, stormy, sunny, warm, wet or windy), avalanche conditions (slab avalanches today or yesterday, whumping or drum-like sounds or shooting cracks, 30cm+ of new snow or significant drifting or rain in the last 48h hours, or rapid temperature rise to near zero degrees or wet surface snow)	1
	danger signs, avalanches, weather, snowpack, snow profiles and possibility to upload pictures	regObs (twin app of 5)

Table A1.1: Additional information gathered on the smartphone applications, either through the interviews or by using the apps during the winter season 2014-2015. The apps are referred to with an ID Number: 1. Avalanche Canada, 2. Utah Avalanche Center, 3. Avalanche Forecast, 4. White Risk, 5. Varsom and 6. SnowSafe.(continued)

Language	English	2, 1, 3
	Avalanche problems in English, the rest in Norwegian	5
	Danger level in English, the rest in German or Slovakian	6
	3 of the 4 Swiss official languages i.e. German, French, and Italian as well as English.	4
Future update content	Introduce or upgrade the possibility for users to report observations or incidents	6, 4, 2, 1
	enable users to store the forecast in order to view it where there is no internet coverage	1
Operating system	IOS (Apple Inc.)	All apps
	Android (Google Inc.)	4, 1, 6, 3
	Possible on Android but website version	5
Standard for data collection from warning center*	CAAML	6, 3
	Other standard/directly from the websites	3
Funding	Fully public	5
	Public completed by corporate or NGO funds	1, 4
	Financed by the developer	6, 3
Regulation	No regulation to follow	1, 4, 6, 2, 5
	Agreement on the use of data with one warning service center	3
Terms of Use/Disclaimer	Mainly: warning that completeness, accuracy and/or precision of information is not guaranteed, mention that the apps are not liable for potential damages and losses Often: bulletin does not replace practical training	5 of the six app

*Only for apps that not developed by warning services

8.2 ANNEX A2: QUESTIONNAIRE ON THE RISK COMMUNICATION CONTEXT IN THE UBAYE VALLEY

This questionnaire was distributed, in French, to stakeholders involved in risk management in the Ubaye valley during the first semester of 2012. For more details see Section 4.2.2.1.

Questionnaire for the stakeholders involved in risk management in the Ubaye valley

Madam, Sir,

The communes from the Ubaye valley are engaged in the protection of the hydro-meteorological hazards and risks related. In order to provide scientific reflection elements on practices and procedures of risk management (prevention, preparedness, response and recovery phases), we ask you your opinion today as involved actor.

We are academics and scientists from the universities of Strasbourg (France), Delft (the Netherlands), Dortmund (Germany), Lausanne (Switzerland), of the National Research Council of Padua (Italy) and of the Institute of Urban Development of Krakow (Poland). We are part of the European research project CHANGES (www.changes-itn.eu) which follows the European research project MOUNTAIN RISKS in which natural hazards of the Ubaye valley were already studied.

The objective of this questionnaire is to better know the opinions and practices of the risk and crisis managers in terms of their needs of information and of the communication to the population. The results of this survey will be the base of further researches that will be conducted in the valley on the topics of risk communication, management and governance strategies, early warning and decision support systems. It takes approximately 30 minutes to complete

We would like to precise that this questionnaire is anonymous. The gathered information will be analyze as a whole and compared to similar information from other case studies in other European countries.

Thank you for your participation.

.

Public awareness and preparedness

1. In your opinion, which of the following groups of the population of the Ubaye valley is more aware of hydro-meteorological hazards and associated risks? Please choose the more aware group in the following propositions.

People living in hazard prone area	☐	vs.	☐	People not living in hazard prone area
Adults (>18 years)	☐	vs.	☐	Children (<18 years)
Young adults (18-25 years)	☐	vs.	☐	Elderly (>65 years)
Men	☐	vs.	☐	Women
Members of families living in the valley for at least a generation	☐	vs.	☐	Members of newly settled families
People that already have experienced natural hazards	☐	vs.	☐	People that never have experienced natural hazards
Population of the valley	☐	vs.	☐	Tourists
Businesses and development agencies	☐	vs.	☐	Population of the valley
Risk and crisis managers	☐	vs.	☐	Population of the valley

2. In your opinion, what is the definition of 'awareness to hydro-meteorological hazards and associated risks'? Please give an answer in one or two sentences.

3. In your opinion, which of the following groups of the population of the Ubaye valley is more prepared to hydro-meteorological hazards and associated risks? Please choose the more prepared group in the following propositions.

People living in hazard prone area	☐	vs.	☐	People not living in hazard prone area
Adults (>18 years)	☐	vs.	☐	Children (<18 years)
Young adults (18-25 years)	☐	vs.	☐	Elderly (>65 years)
Men	☐	vs.	☐	Women
Members of families living in the valley for at least a generation	☐	vs.	☐	Members of newly settled families
People that already have experienced natural hazards	☐	vs.	☐	People that never have experienced natural hazards
Population of the valley	☐	vs.	☐	Tourists
Businesses and development agencies	☐	vs.	☐	Population of the valley
Risk and crisis managers	☐	vs.	☐	Population of the valley

4. In your opinion what is the definition of 'preparedness to hydro-meteorological hazards and associated risks'? Please give an answer in one or two sentences.

Communication and information to the population

5. Which of the following media have been used to spread information on hydro-meteorological hazards and related risks to the population of the Ubaye valley? If they have been used (if yes), please rate their effectiveness (was the media appropriate to convey the message and meet the goal of the communication?).

	Yes	No	Extremely effective	Effective	Neither effective nor not effective	Not really effective	Not effective at all
Local/regional press							
Local/regional radio							
Local/regional TV							
Internet							
Text messages							
Smartphone applications							
Information boards in public spaces							
Public meetings							
Leaflets of the municipality							
Flyers and brochures							
Door-to-door communication							
Other, specify							

6. How often in the past 5 years were the following topics addressed to the population of the Ubaye valley?

	Never	1 time	2-5 times	More than 5 times
Risk zoning and land use legislation				
The actions taken by the authorities to minimize risk				
The individual preventive measures that people can take				
The causes of risk				
The potential consequences of a future event				
The evacuation plan and emergency procedures				
Warnings to the community				
Structural mitigation measures (e.g. dykes)				
Technical/scientific research outputs				

7. For each of the following audiences, please indicate whether:
- the following topics were especially communicated to them in the past,
- you think that the audience would like to receive more information about them and
- you think they should be especially communicated to them in the future? Please tick the boxes that correspond to the appropriate answers and leave them blank if it is not the case.

CHILDREN (< 18 years)	Risk zoning/land use legislation	Actions taken by the authorities to minimize risk	Individual preventive measures	Causes of risk	Potential consequences of a future event	Evacuation plan and emergency procedures	Warnings to community	Structural mitigation measures (e.g. dykes)	Technical/academic research outputs
The topic was communicated in the past to this group									
This group would like want more information on the topic									
This topic should be communicated in the future to this group (again or for the first time)									

ADULTS (18-65 years)	Risk zoning/land use legislation	Actions taken by the authorities to minimize risk	Individual preventive measures	Causes of risk	Potential consequences of a future event	Evacuation plan and emergency procedures	Warnings to community	Structural mitigation measures (e.g. dykes)	Technical/academic research outputs
The topic was communicated in the past to this group									
This group would like want more information on the topic									
This topic should be communicated in the future to this group (again or for the first time)									

ELDERLY PEOPLE (> 65 years)	Risk zoning/land use legislation	Actions taken by the authorities to minimize risk	Individual preventive measures	Causes of risk	Potential consequences of a future event	Evacuation plan and emergency procedures	Warnings to community	Structural mitigation measures (e.g. dykes)	Technical/academic research outputs
The topic was communicated in the past to this group									
This group would like want more information on the topic									
This topic should be communicated in the future to this group (again or for the first time)									

NEW RESIDENTS	Risk zoning/land use legislation	Actions taken by the authorities to minimize risk	Individual preventive measures	Causes of risk	Potential consequences of a future event	Evacuation plan and emergency procedures	Warnings to community	Structural mitigation measures (e.g. dykes)	Technical/academic research outputs
The topic was communicated in the past to this group									
This group would like want more information on the topic									
This topic should be communicated in the future to this group (again or for the first time)									

BUSINESS AND DEVELOPMENT AGENCIES	Risk zoning/land use legislation	Actions taken by the authorities to minimize risk	Individual preventive measures	Causes of risk	Potential consequences of a future event	Evacuation plan and emergency procedures	Warnings to community	Structural mitigation measures (e.g. dykes)	Technical/academic research outputs
The topic was communicated in the past to this group									
This group would like want more information on the topic									
This topic should be communicated in the future to this group (again or for the first time)									

TOURISTS	Risk zoning/land use legislation	Actions taken by the authorities to minimize risk	Individual preventive measures	Causes of risk	Potential consequences of a future event	Evacuation plan and emergency procedures	Warnings to community	Structural mitigation measures (e.g. dykes)	Technical/academic research outputs
The topic was communicated in the past to this group									
This group would like want more information on the topic									
This topic should be communicated in the future to this group (again or for the first time)									

8. Is there legal requirements that makes it compulsory for your 'organisation' to communicate/spread information on topics related to the following phases of the risk management?

	Yes	If yes, which law	No	I do not know
Prevention (mitigation measure)				
Preparedness (to a potential crisis)				
Response (during crisis)				
Recovery (return to the normal state, after the crisis)				

9. In your opinion and in general (not limited to your 'organisation') should measures be taken to improve communication/information to the population of the Ubaye valley during the following phases of risk management?

	Yes	No	I do not know
Prevention (mitigation measure)			
Preparedness (to a potential crisis)			
Response (during crisis)			
Recovery (return to the normal state, after the crisis)			

10. Please rank the following phases of risk management, in terms of priority (importance) for communication? Place the numbers 1 to 4 in the boxes, 1 being the phase that has most priority and 4 the least.

Prevention (mitigation measure)	
Preparedness (to a potential crisis)	
Response (during crisis)	
Recovery (return to the normal state, after the crisis)	

11. Do you think communication/information is equally important as a tool of prevention as well as preparedness? If not, for which of the two do you think it is more relevant?

	Yes
	No (please specify if possible for which of the phases, communication on is more relevant and explain briefly your choice.

12. Do you think it is important to communicate/to inform the population about uncertainty related to hydro-meteorological hazards and associated risks?

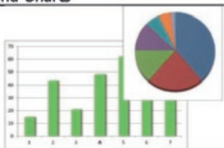
Yes	No	I do not know

13. In your opinion, which is the best form to communicate/to inform the population about uncertainty? Please choose the best form for each of the propositions.

Numerical form		vs.		Text descriptions
Text descriptions		vs.		Visual elements
Visual elements		vs.		Numerical form
Probability of occurrence (0 to 1)		vs.		Return periods
Words such as 'likely, unlikely,...'		vs.		Words such as 'dangerous, probably dangerous...'
Variation of colour of the same symbol		vs.		Variation of size of the same symbol
Different colours		vs.		Different shades of the same colour

14. In your opinion, what are the appropriate **visualization tools** **to communicate/inform on risk related information to the following audiences?** Several answers are possible for each visualization tool. Please note that you are asked to evaluate the use of the tools and not the content that is presented here. This are only examples.

Graphs and Charts



	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Pictures

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Movies

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Smartphone applications

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

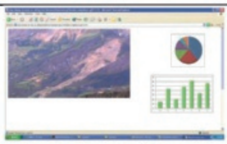
Static maps (on paper or digital)

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Interactive environments (softwares)

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Websites



	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Information boards

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

Objects

	Children (<18 years)		Businesses
	Adults (18-65 years)		Tourists
	Elderly people (>65 years)		Risk and crisis managers

15. In your opinion what is the best way to issue a hydro-meteorological hazard warning to the population of the Ubaye valley? Please tick the boxes on the left of the two preferred answers.

	Radio		Land phone calling
	Television		Emails
	Acoustic signal (siren, loudspeaker)		Web platform
	Text message to cell phone		Door-to-door
	Other, please specify		

8.3 ANNEX A3: CONTENT OF THE 'ALERTE' EXHIBITION

This annex presents the various exhibits that constituted the French version of the 'Alerte' exhibition. See Chapters 4, 5 and 6 for more details.

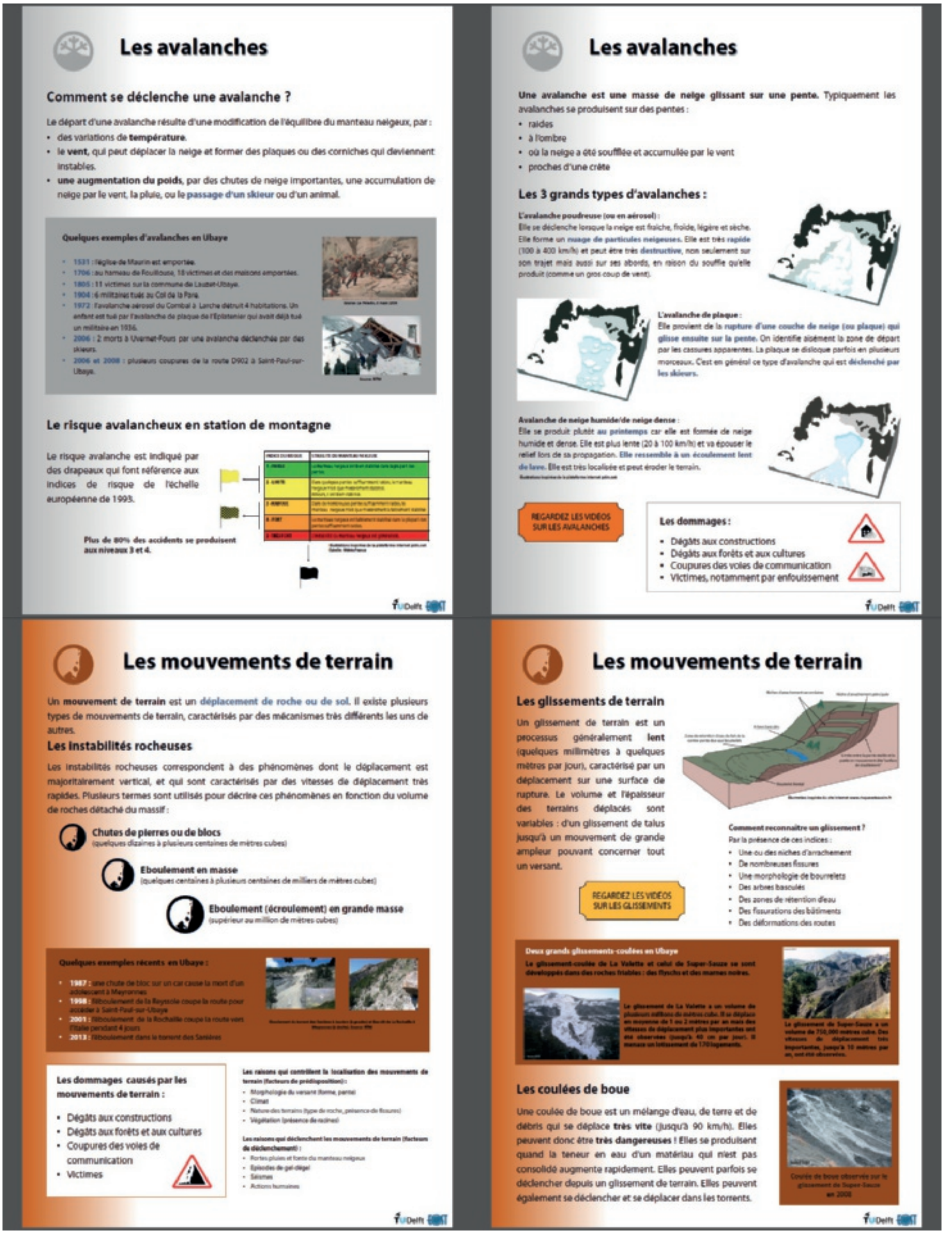


Figure A3.1: Posters on avalanches and landslides presented at "Alerte" exhibition in France

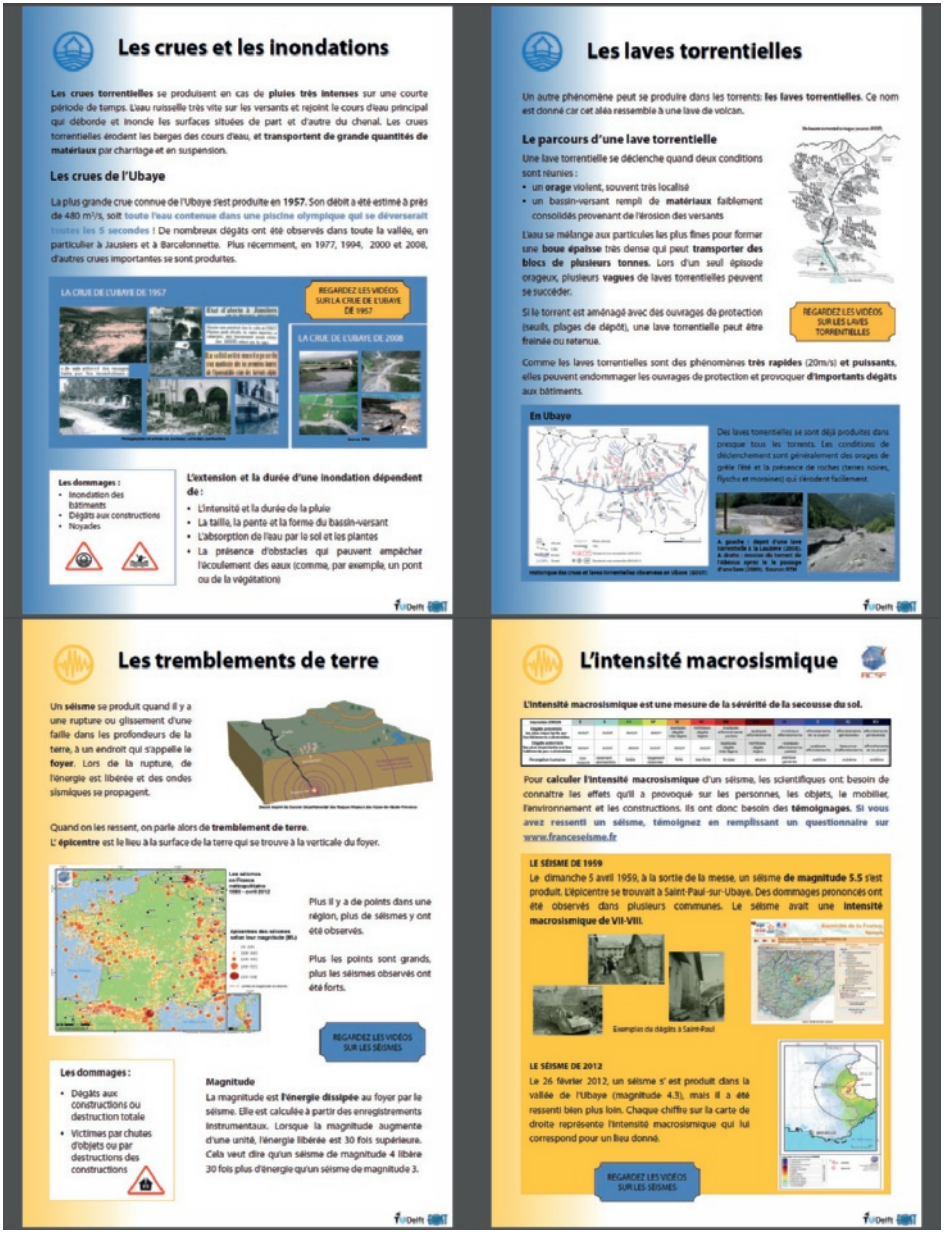


Figure A3.2: Posters on torrential floods, debris flows and earthquakes presented at “Alerte” exhibition in France

Figure A3.3: Posters on risk, security guidelines and non-structural mitigation measures presented at "Alerte" exhibition in France

Figure A3.4: Posters on structural mitigation measures presented at “Alerte” exhibition in France

Figure A3.5: Supporting information boards on avalanches, landslides, earthquakes, return period and non-structural mitigation measures presented at “Alerte” exhibition in France

Figure A3.6: Supporting information boards on security guidelines and-structural mitigation measures presented at “Alerte” exhibition in France

Figure A3.7: Clockwise: Timeline poster, flood scale model, videos of events and seismograph presented at “Alerte” exhibition in France

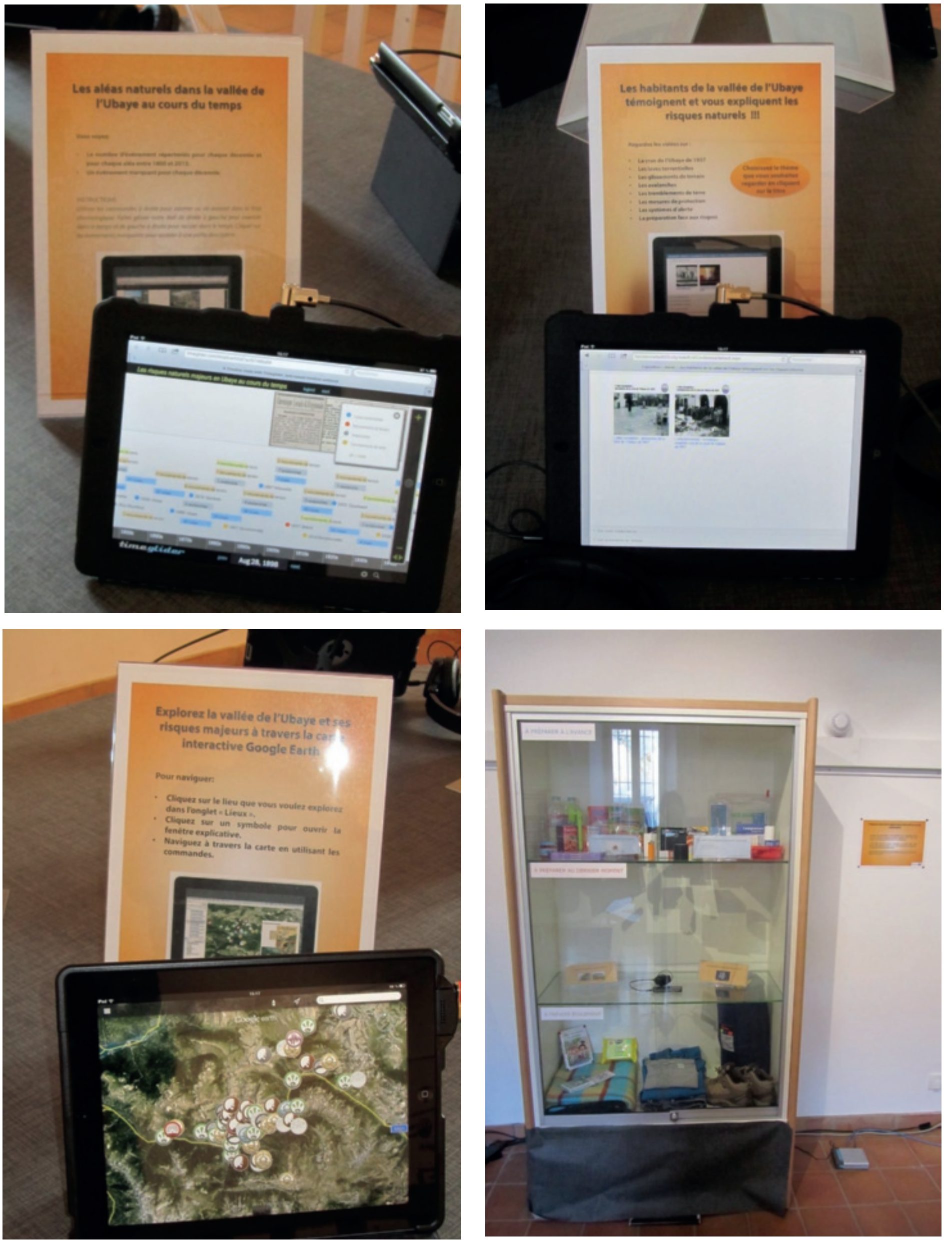


Figure A3.8: Clockwise: Numerical timeline poster, videos of testimonies, emergency kit and Google Earth map presented at "Alerte" exhibition in France

8.4 ANNEX A4: DISSEMINATION REPORT ON THE EFFECTIVENESS OF THE 'ALERTE' EXHIBITION

This written report, presenting the results of the study on the effectiveness of the 'Alerte' exhibition was disseminated in January 2016 to all relevant local stakeholders of the Ubaye valley. See Section 4.5 for more details.

EXPOSITION « ALERTE » : SENSIBILISATION AUX RISQUES NATURELS DANS LA VALLÉE DE L'UBAYE

RÉSUMÉ DES RÉSULTATS D'UNE RECHERCHE MENÉE ENTRE 2012 ET 2015 DANS LE CADRE DU PROJET DE RECHERCHE EUROPÉEN « CHANGES »

BUT DE L'ÉTUDE

CRÉER UNE EXPOSTION SUR LES RISQUES NATURELS DANS LA VALLÉE DE L'UBAYE, AFIN DE MESURER SON ÉFFICACITÉ EN TERMES D'AUGMENTATION DE LA SENSIBILISATION DU GRAND PUBLIC

TUDelft Delft University of Technology

cnrs EOST École et Observatoire des Sciences de la Terre Université de Strasbourg

CHANGES Risk-HVA

CONTEXTE DE L'ÉTUDE

Ce document résume les résultats d'une étude conduite entre 2012 et 2015 dans le cadre du projet de recherche européen 'CHANGES' par Marie Charrière de l'Université Technologique de Delft (Pays-Bas). Ce projet a été soutenu par le Centre National de la Recherche Scientifique (CNRS) et l'Université de Strasbourg avec la coopération de la Médiathèque de Barcelonnette, de la Municipalité de Barcelonnette, des Services de Restauration des Terrains de Montagne, de l'Association Séolane, de la Région Provence-Alpes-Côte d'Azur, du Conseil de l'Europe, de l'Accord Européen et Méditerranéen des Risques Majeurs, du Bureau Central Sismologique Français, du Réseau National de Surveillance Sismique et du projet de recherche européen 'KULTURISK'.

Nous espérons que cette information aidera aux futures prises de décisions dans le domaine de la sensibilisation aux risques naturels.

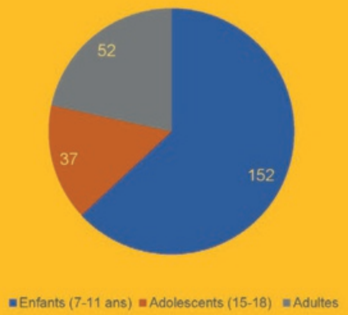
L'EXPOSITION « ALERTE : connaître les risques en montagne, c'est y être mieux préparé »

Exposée à la Médiathèque de Barcelonnette du 4 décembre 2013 au 19 février 2014.

Elle a illustré les dangers naturels que sont les avalanches, les glissements de terrain, les inondations, les laves torrentielles et les séismes avec des exemples locaux, ainsi que les outils de gestion des risques qui y sont liés au moyen de :

- posters
- chronologies des évènements
- maquette d'inondation
- sismographe
- vidéos d'évènements
- vidéos de témoignages
- carte interactive
- kit d'urgence

241 PARTICIPANTS



MÉTHODES D'ÉVALUATION

Mesurer l'impact de l'exposition sur la sensibilisation :
Enquêtes avant et après l'exposition avec les mêmes questions pour voir si les opinions ont changé.

Mesurer la satisfaction des visiteurs quant à l'exposition :
Enquête **après** l'exposition.

Mesurer l'attrait des différentes pièces de l'exposition :
Suivi du parcours des visiteurs dans l'exposition au moyen d'un système de radio-identification (RFID).

APERÇU DES RÉSULTATS DE L'ÉTUDE

L'EXPOSITION A-T-ELLE SENSIBILISÉ LES PARTICIPANTS AUX RISQUES NATURELS ? A-T-ELLE PLU ? QUELLES PIÈCES ONT-ELLES EU LE PLUS D'ATTRAIT ?

Sensibilisation aux risques naturels

Ce qui a augmenté après la visite de l'exposition

- La sensibilisation des adolescents et des adultes aux risques naturels. Cela est plus particulièrement le cas pour les participants qui n'ont pas ou peu vécu de dangers naturels et/ou qui n'ont reçu que peu d'information sur ce sujet au préalable.
- Les adultes pensent mieux connaître la façon d'agir en cas d'urgence.
- La préparation des adultes et enfants face aux risques naturels.
- Le sentiment de vulnérabilité des adolescents, comme s'ils avaient réalisé qu'ils vivent dans une région à risque.
- La perception de la sévérité des conséquences en cas d'inondation.
- L'inquiétude des adolescents et des enfants face aux inondations ainsi que leur perception de la probabilité qu'un danger naturel de ce type se produise dans la vallée de l'Ubaye.
- L'inquiétude des adolescents face aux laves torrentielles comme leur perception de la sévérité des conséquences liées à ce même danger naturel et aux avalanches.

Ce qui a n'a pas changé après la visite de l'exposition

Les indicateurs de sensibilisation aux séismes et aux glissements de terrain.

Deux idées fausses révélées :

- Les participants pensent que les séismes se produisent plus souvent dans la vallée de l'Ubaye que les phénomènes torrentiels.
- Les participants pensent que les laves torrentielles se produisent principalement au printemps alors que celles-ci se produisent généralement en été.

Satisfaction

Les visiteurs sont satisfaits

- 85% d'entre eux ont aimé l'exposition,
- 77% l'ont trouvée belle,
- et 73% ont trouvé la présentation appropriée.

En termes de contenu, les résultats sont plus tranchés

- 60% ont appris de nouvelles choses,
- 53% ont été surpris par le contenu,
- et 44% ont changé d'avis sur les risques naturels grâce à la visite de l'exposition.

Attrait des éléments visuels

Les éléments visuels regardés le plus de fois

Enfants	Adolescents	Adultes
•Sismographe	•Maquette	•Poster inondations
•Chronologie	•Sismographe	•Chronologie
•Maquette	•Poster inondations	•Vidéos d'évènements

Les éléments visuels regardés le plus longtemps

Enfants	Adolescents	Adultes
•Sismographe	•Vidéos de témoignages	•Chronologie
•Vidéos d'évènements	•Sismographe	•Vidéos de témoignages
•Vidéos de témoignages	•Chronologie	•Poster inondations

➔ Les pièces interactives et celles qui traitent des processus naturels sont les plus attrayantes.

Conclusions et recommandations

- La sensibilisation aux dangers naturels des participants a globalement augmenté et les participants ont été satisfaits de l'exposition.
- Puisque la sensibilisation des adultes n'a augmenté que pour des questions générales et non spécifiques aux dangers naturels, il peut être supposé qu'une campagne de sensibilisation présentant plusieurs dangers n'est pas la meilleure option pour ce public, mais que des campagnes sur un seul danger seraient peut-être plus appropriées.
- Une exposition semble être plus efficace pour sensibiliser sur les dangers qui ne se produisent que rarement dans la vallée de l'Ubaye, comme les inondations. Pour les dangers plus fréquents et qui se produisent localement, d'autres moyens de communication doivent être envisagés.
- De manière générale, les moyens de communication interactifs sont à favoriser.
- Une campagne de sensibilisation sur les laves torrentielles serait nécessaire pour gommer les idées fausses qui leur sont associées.
- La priorité de la communication doit être donnée aux personnes qui n'ont jamais ou peu vécu de dangers.

Les porteurs du projet sont très reconnaissants de l'appui constant apporté par la Communauté de Communes Vallée de l'Ubaye, du Syndicat Mixte de Protection contre les Crues Ubaye-Ubayette, du Peloton de Gendarmerie de Haute Montagne de Jausiers, des Pompiers de Barcelonnette, du Jardin des Sciences de l'Université de Strasbourg, de l'Équipe mobile académique de liaison et d'animation et de l'Association Nationale de l'Étude de la Neige et des Avalanches ; ainsi que des habitants de la vallée qui ont mis à la disposition de l'exposition leurs témoignages et documents : Valentine Allione, Pierre-Martin Charpenel, Jean-Pierre et Nicole Chevalier, Michel Isaïa, Michel Longeron, Émile Tron, Jacqueline Reynier, Madame Collomb et Madame Lequette.

Nous remercions très sincèrement les participants à l'étude en particulier les enfants et adolescents de l'École primaire communale de Barcelonnette, de l'École Saint-Joseph, de l'École primaire de Saint-Paul-sur-Ubaye, du Collège André Honorat et de la Maison des Jeunes de Barcelonnettes ainsi les adultes de Club Culturel, de la Sabenca, du CCAS-Sauze, du CCAS-Méolans et du Parc du Mercantour.

Contacts en cas de questions sur l'étude ou sur le matériel de l'exposition

Université Technologique de Delft
Marie Charrière
macharriere@gmail.com

Thom Bogaard
t.a.bogaard@tudelft.nl
+31 15 278 42 86

Université de Strasbourg
Jean-Philippe Malet
+33 (0)3 68 85 00 36
jeanphilippe.malet@unistra.fr

8.5 ANNEX A5: DISSEMINATION REPORT OF PREVIOUS RESEARCH RESULTS

This dissemination report is derived from the research made by Angignard (2011). It was written in collaboration with Teresa Sprague, a fellow PhD student of the Changes project and distributed to relevant local stakeholders in the Ubaye Valley in July 2012 to restore trust. See Section 4.6.3 for more details.

LES GENS DE LA VALLEE DE L'UBAYE ET LES RISQUES NATURELS

EXECUTIVE SUMMARY OF RESULTS OF THE MOUNTAIN RISKS SURVEY

Summary of Mountain Risk Questionnaire Results

Brief Acknowledgement

This document provides a summary of the results of the survey conducted by Dr. Marjory Angignard of TU Dortmund as part the European research project, Mountain Risks. The project was supported by the Centre National de la Recherche Scientifique of the University of Strasbourg with the cooperation and support of the mayors of participating communities.

The information provided from the survey has been summarized, reformatted and edited by Teresa Sprague of the CHANGES project and is reviewed with the collaboration of TU Dortmund, the Centre National de la Recherche Scientifique of the University of Strasbourg and TU Delft.

We greatly thank all those who participated in the survey. We are also very grateful for the support of the mayors of the communities and hope that this information will help assist future decision making about natural risks.

SUMMARY OF MOUNTAIN RISK SURVEY RESULTS

This first section provides the logistics, analysis, and demographic distributions of the survey as well as some important points revealed from this information. The next section provides categories of learning points and some recommendations found through analysis of the survey results.

Important Points

The results are a product of those who responded. Though important learning points and recommendations can be made based on the information provided, it should not be taken as a direct representation of the entire population of the Ubaye Valley.

It is also important to note that some 'groups' (based on age and gender) are more represented or less represented than other groups.

LOGISTICAL INFORMATION

A total of 2120 surveys were sent to several municipalities in June 2009. By September that year, 344 completed surveys were received. The number returned varied by commune as follows:

Commune	Envoyés	Retournés
Barcelonnette	1280	190 (15%)
Faucon de Barcelonnette	100	22 (22%)
Jausiers	440	63 (14%)
St Pons	300	69 (23%)
Total	**2120**	**344 (16%)**

The results presented in this document indicate only information from inhabitants who chose to respond. The results should therefore not be considered universal for the entire population but only for those who responded.

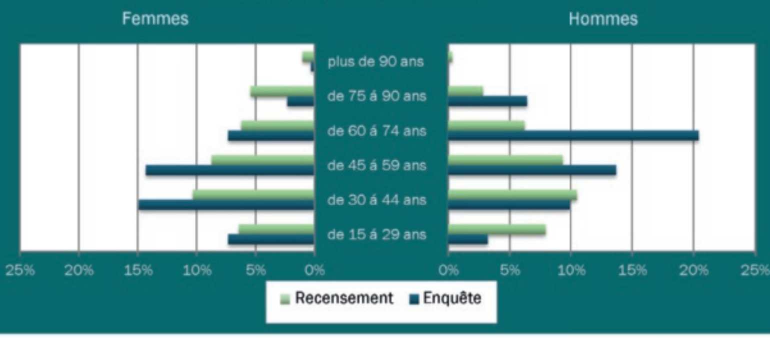
ANALYSIS OF RESPONSES

Responses were analysed to determine patterns, or trends, in the information respondents provided. Trends were observed based on age, gender, duration and type of residency in the Ubaye Valley. The observations provided from these results help indicate respondents' risk awareness, concerns, and perceptions of how risks are managed in the Ubaye Valley. This includes how respondents view available risk information and the actors involved in the management of natural risks. Observations especially provide helpful insight into risk communication and informational needs.

DEMOGRAPHIC DISTRIBUTION OF RESPONDENTS

Of the surveys returned, there was an over-representation of older men ages 60-74 and women ages 45 to 59. There was also an under-representation of men under age 45 and women ages 75-90.

Une surreprésentation peut marquer l'intérêt d'un groupe pour le sujet des risques naturels, ou une motivation accrue à répondre. Ainsi, pour les hommes de 60 à 90 ans on peut évoquer "l'effet grand-père" : ils aiment partager leur expérience et leur connaissance des spécificités locales. Cela nous a été en partie confirmé sur le terrain, où nous avons rencontré des "papys" qui s'intéressaient au sujet de notre étude et voulaient nous faire part de leur vécu.



CATEGORIES OF LEARNING POINTS & RECOMMENDATIONS

The following categories listed provide a series of learning points and some recommendations that have been revealed through the results of the survey.

OBSERVED LEVEL OF PUBLIC AWARENESS

A large majority indicate they know of the existence of natural risks in the area and approximately 1/4th have experienced these risks.
-This indicates a significant degree of public awareness.

Though respondents seemed overall aware of natural hazards impacting their community, they felt they would not personally be affected.
-This indicates a low degree of incentive for self-preparedness.

IMPORTANT POINTS FOR IMPROVING COMMUNICATION OF NATURAL RISKS

There is a general demand for more information as over 80% indicated they would like to receive more information. Additionally, over 80% indicated they would attend a public meeting (and discussion) on natural risks.
-This indicates a need for providing more information and for providing more opportunities for public involvement.

Younger groups are less well informed and had more requests for information than older groups. New residents also requested more information than those who have been established in the Valley for 3 or more generations.
-This indicates a need to target younger groups and new residents in communication campaigns.

10% of respondents indicated they felt they have no information at all while 30% of respondents stated they rely on only unsolicited information. 20% of respondents search for information themselves, though these respondents tended to be those who have previously experienced a natural hazard.
-This indicates the importance of the need to provide information to the public. This is especially important as only 1/4th of respondents indicated they have experienced a hazard and are consequentially more likely to look up information themselves.

INFORMATIONAL TOPICS OF INTEREST FOR RESPONDENTS

Respondents were most interested in information concerning evacuation and emergency procedures.
-This indicates a potential interest in understanding procedures that must be followed during a crisis.

Risk zoning was also indicated as an important topic in which residents would like to receive more information.
-This indicates a potential interest in understanding legally required procedures.

Respondents who have not been personally affected by a natural disaster were interested in receiving more information about the physical consequence to buildings and infrastructure. Those respondents who have been personally affected were more interested in receiving more information about how land use legislation is enforced.
-This indicates a significant difference in informational needs depending on whether respondents have or have not experienced a natural hazard. This implies the latter informational request might increase should more residents experience natural hazards.

Recommendations

Overall, providing more information about natural hazards and related risks can address the general demand for more information indicated by respondents.

Efforts made in communicating information on natural hazards and related risks to the public could benefit from increased opportunities for public involvement. Communication efforts targeting younger age groups and new residents would be especially beneficial.

Topics of information that may further address the stated needs of the public are procedures that might be followed during crisis.

Conclusions

Respondents are generally aware that risks exists in their commune. However, they do not feel personally at risk.

There are informational gaps that could be addressed and could be beneficial to the stated needs of the public.

2

OBSERVED DIFFERENCES IN GENDER

Men tended to rate hazards as less dangerous than did women and tended to rate the probabilities of landslides and flooding as less likely to occur than did women. Men also seemed to feel better informed than did women.
-This indicates women tend to be more concerned and feel less knowledgeable, less prepared, and generally more vulnerable than men.

Woman asked for 'educational' types of information while men asked for more 'during event' and technical information.
This indicates a need to account for gender specific preferences in types of information provided in communication campaigns.

OBSERVED DIFFERENCED AMONG COMMUNES

Faucon respondents were most concerned with coulees de debris and overall tended to think hazards as less probable than did the other communes. Opposite to Faucon, respondents in **Barcelonnette** tended to think of hazards as more probable than did the other communes. Respondents in **Jausiers** were more concerned with floods than landslides while in **San Pons** this was the opposite; respondents were more concerned with landslides than floods.
-This indicates that concerns are not uniform within the Ubaye Valley but rather vary by commune.

IMPORTANT POINTS FOR ACTORS INVOLVED WITH NATURAL HAZARDS

Information from local authorities is more trusted than information from regional or state authorities. More trust is especially placed in technicians and field actors (such as the RTM). This latter group is deemed more trustworthy, more knowledgeable, and more prepared to handle emergencies.
-This indicates the general trend that 'the more local, the more trusted' and reveals a stronger level of trust in the municipality.

Though the media was selected as a source of information, respondents indicated a low level of trust. This is similar for insurance companies and also applies to the knowledge and preparedness of these actors.
-This indicates a low confidence in the media and insurance companies as actors involved with natural risks.

The 'Top 3' most prepared actors in the case of emergency were stated to be the civil security (e.g. police, fire department), RTM, and the municipality while the least prepared were media, insurance, and the population.
-This indicates, similarly to what is legally required, that local authorities and technicians are considered most prepared to handle an emergency.

Recommendations

Efforts in communicating information about natural hazards and related risks should address gender specific informational needs.

Efforts should target especially informational needs of women.

Conclusions

Concern for types of natural hazards differs by commune.

Respondents place more trust in and have a higher opinion of local actors, especially field actors. Respondents tend to distrust and have a low opinion of the media and insurance companies.

Main Conclusion

The summary of the 344 responses from members of the population of Ubaye provides information especially for future communication campaigns according to the needs respondents have stated. Future strategies toward reducing natural risks can adapt and benefit from the input provided by respondents.

In general, it is hoped that the summary within this brief document might provide information for and assist in future decision-making processes and overall management of natural risks in the Ubaye Valley.

Supporting Institutions and Networks

The institutions below have supported and contributed in the production of this document. The research networks (Mountain Risks, CHANGES) that funded these production efforts are also provided.

Contact for further Inquiries

Agust-Schmidt-Str. 10
44227 Dortmund
Germany

0231/755-2439 Phone
0231/755-4788 Fax

Teresa.sprague@tu-dortmund.de

8.6 ANNEX A6: PRE-TEST AND POST-TEST QUESTIONNAIRES USED TO ASSESS THE EFFECTIVENESS OF THE 'ALERTE' EXHIBITION

This annex presents the questionnaires of the pre-test/post-test research design that was used to assess the effectiveness of the 'Alerte' exhibition in the Ubaye valley between December 2013 and July 2014 with adults and teenagers. Note that these questionnaires were distributed in the mother-tongue of the participants, i.e. French. Questionnaires distributed to children contained less questions. For more details see Section 5.2.2.

Pre-test for adults and teenagers

1. **In general do you worry about…?**
   Please choose between 1 = not at all and 5 = a lot

	1 = not at all	2	3	4	5 = a lot	I do not know
Terrorism						
Floods						
Landslides						
Economic crisis						
Debris flows						
Epidemics						
Food security						
Earthquakes						
Snow avalanches						

2. **How often have you experienced the following natural hazards?**
   Please put a cross in the right box

	Never	Once	2-5 times	6 -10 times	More than 10 times	I don't want to answer
Snow avalanches						
Floods						
Landslides						
Debris flows						
Earthquakes						

3. **Have you ever experienced health problems or suffered damages as a results of the occurrence of any of these natural hazards?**
   Please put a cross in the right box

	Yes	No	I do not know
Snow avalanches			
Floods			
Landslides			
Debris flows			
Earthquakes			

4. Do you know somebody that has experienced health problems or suffered damage of the occurrence of these natural hazards?

Please put a cross in the right box

	Yes	No	I do not know
Snow avalanches			
Floods			
Landslides			
Debris flows			
Earthquakes			

5. How long have your been living in the Ubaye valley?

- ☐ I do not live in the Ubaye valley. Please precise where you do:
- ☐ Less than 1 year
- ☐ 1-5 years
- ☐ 6-10 years
- ☐ 11-20 years
- ☐ More than 20 years

6. Do you agree with the following?

Please put a cross between 1 = not at all and 5 = completely

I feel aware of natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know

I feel vulnerable to natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know

I feel I have all the knowledge and information to respond to natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know

I feel I have all the material and financial resources to respond to natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know

I feel prepared for natural hazards occuring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know

7. In the next 5 years, how likely is that the following will occur in the Ubaye Valley?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know

Floods					
1 = not at all	2	3	4	5 = a lot	I do not know

Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know

Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know

Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

8. How serious would be the consequences of a/an ..... occurring in the Ubaye Valley?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know

Floods					
1 = not at all	2	3	4	5 = a lot	I do not know

Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know

Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know

Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

9. How much information have you received on .....?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

10. Has this information helped you to be more aware of .....?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

11. Has this information motivated you to take actions/change your behaviour to be more prepare for .....?

Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

12. Gender

☐ Male ☐ Female

13. Age

- ☐ Less than 12 years old
- ☐ 12-18 years old
- ☐ 18-30 years old
- ☐ 31-50 years old
- ☐ 51-70 years old
- ☐ More than 70 years old

14. What is the highest degree you obtained?

- ☐ CAP
- ☐ BEP
- ☐ Bac. prof ou technologique
- ☐ DUT
- ☐ BTS
- ☐ Ingénieur
- ☐ Bac. général
- ☐ DEUG
- ☐ Licence
- ☐ Maitrise
- ☐ DEA
- ☐ DESS
- ☐ Autre, précisez:

15. Is your work somehow related to the topic of natural hazards and associated risks?

☐ Yes ☐ No

Post-test and satisfaction survey (i.e. questions 4 and 5) for adults and teenagers

1. **How much new information have you received by visiting this exhibition on the following?**
   Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

2. Has this new information helped you to be more aware of .....?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

3. Has this new information motivated you to take actions/change your behaviour to be more prepare for .....?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

4. Do you agree with the following ?
Please put a cross between 1 = not at all and 5 = a lot

I liked the exhibition					
1 = not at all	2	3	4	5 = a lot	I don't know

This exhibition changed my views on natural hazards and associated risks					
1 = not at all	2	3	4	5 = a lot	I don't know

I learned new things					
1 = not at all	2	3	4	5 = a lot	I don't know

The content of the exhibition surprised me					
1 = not at all	2	3	4	5 = a lot	I don't know

The presentation of the exhibition is appropriate					
1 = not at all	2	3	4	5 = a lot	I don't know

The exhibition is beautiful					
1 = not at all	2	3	4	5 = a lot	I don't know

5. How did you like the different parts of the exhibition ?
Please put a cross between 1 = not at all and 5 = a lot

	1 = not at all	2	3	4	5 = a lot	I don't know
Videos of inhabitants						
Videos of events						
Mock-up						
Seismograph						
Interactive map						
Timeline on poster						
Interactive timeline						
Emergency kit						
Posters on phenomena						
Posters on mitigation measures						
Posters on security guidelines						

6. In general do you worry about…?

Please choose between 1 = not at all and 5 = a lot

	1 = not at all	2	3	4	5 = a lot	I do not know
Terrorism						
Floods						
Landslides						
Economic crisis						
Debris flows						
Epidemics						
Food security						
Earthquakes						
Snow avalanches						

7. Do you agree with the following?

Please put a cross between 1 = not at all and 5 = completely

I feel aware of natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know
I feel vulnerable to natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know
I feel I have all the knowledge and information to respond to natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know
I feel I have all the material and financial resources to respond to natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know
I feel prepared for natural hazards occurring in the Ubaye valley					
1 = not at all	2	3	4	5 = completely	I do not know

8. In the next 5 years, how likely is that the following will occur in the Ubaye Valley?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

9. How serious would be the consequences of a/an ….. occurring in the Ubaye Valley?
Please put a cross between 1 = not at all and 5 = a lot

Snow avalanches					
1 = not at all	2	3	4	5 = a lot	I do not know
Floods					
1 = not at all	2	3	4	5 = a lot	I do not know
Landslides					
1 = not at all	2	3	4	5 = a lot	I do not know
Debris flow					
1 = not at all	2	3	4	5 = a lot	I do not know
Earthquakes					
1 = not at all	2	3	4	5 = a lot	I do not know

10. Why did you visit the exhibition? Several answers possible

- ☐ Because you are already familiar with the topic and you wanted to learn more
- ☐ Because you are not familiar with the topic and you wanted to learn about it
- ☐ Because you always go to the mediatheque exhibitions
- ☐ Because someone told you about it
- ☐ Because someone asked you to come along with him/her
- ☐ Because you are interested in the topic.
- ☐ Because you had nothing else to do
- ☐ Others, specify:

11. How many risk indexes constitute the European scale of avalanche risk ?

- O 3
- O 5
- O 4
- O 6

12. What are the seismic waves used for measuring and locating earthquakes ?

- O S-waves
- O Rayleigh waves
- O P-waves and Rayleigh waves
- O P-waves and S-waves

13. In what year the largest known flood of the Ubaye occurred ?

- O 1856
- O 1977
- O 1957
- O 2008

14. Of what type of landslides are those of La Valette and Super-Sauze ?

- O Mudslide
- O Debris flow
- O Rockslide
- O Mud flow

8.7 ANNEX A7: ADDITIONAL MATERIAL OF THE PUBLISHED PAPER PRESENTED IN CHAPTER 5.

This annex presents the additional material of the published paper presented in Chapter 5. For more details see Sections 5.3.1 to 5.4.4.

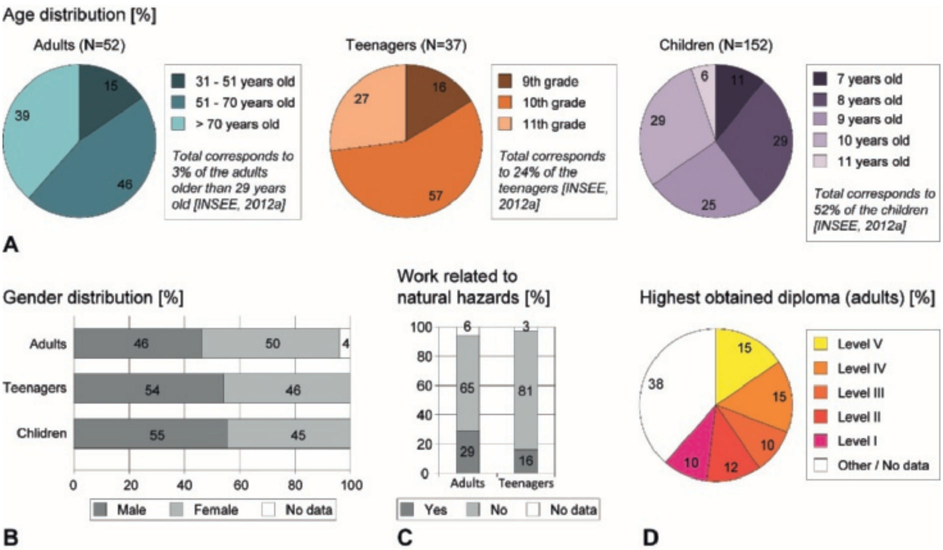


Figure A7.7: Demographic characteristics of the sample. Concerning “diploma”, Level V refers to lower secondary education, Level IV to upper secondary education, Level III to 2 years of education after high school, Level II to a Bachelor degree, and Level I to a Master’s degree or doctorate.

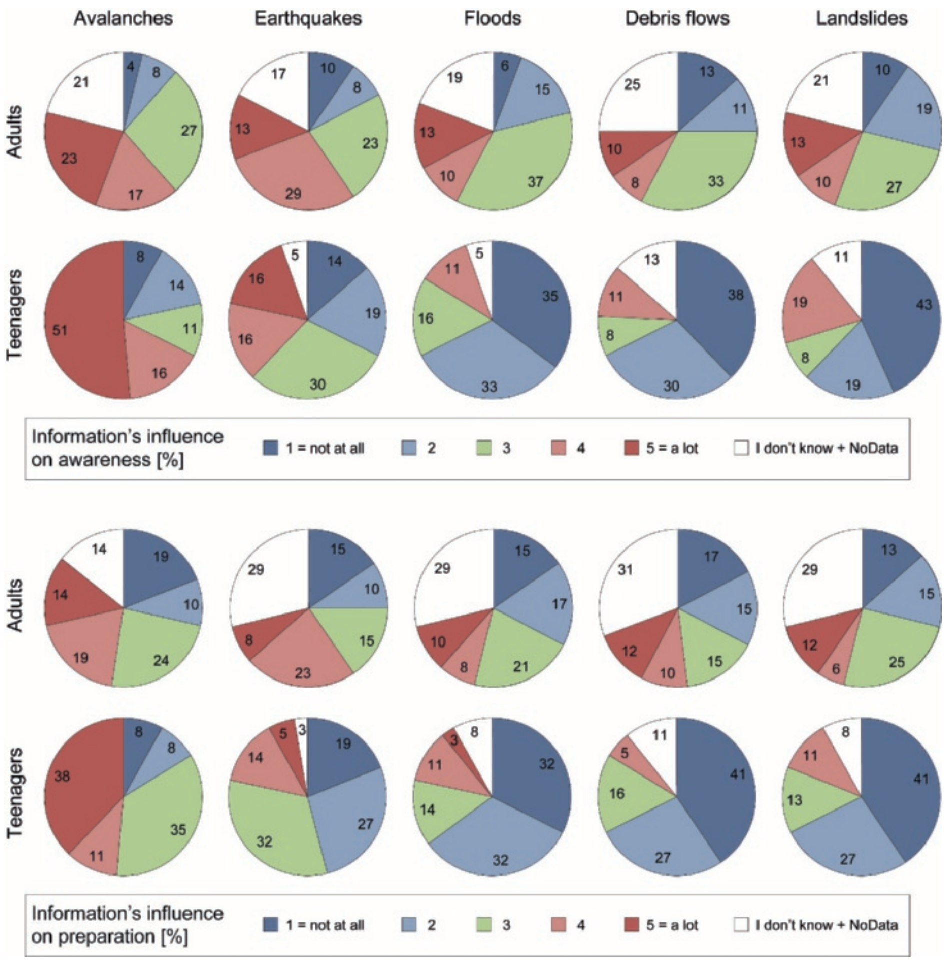


Figure A7.2: Influence of received prior information on the awareness and motivation to become prepared. 1= not at all, 5 = a lot. Questions: "Has this information helped you to be more aware of avalanche/earthquakes/floods/debris flows/landslides?" and "Has this information motivated you to take actions/change your behavior to be more prepare for avalanche/earthquakes/floods/debris flows/landslides?"

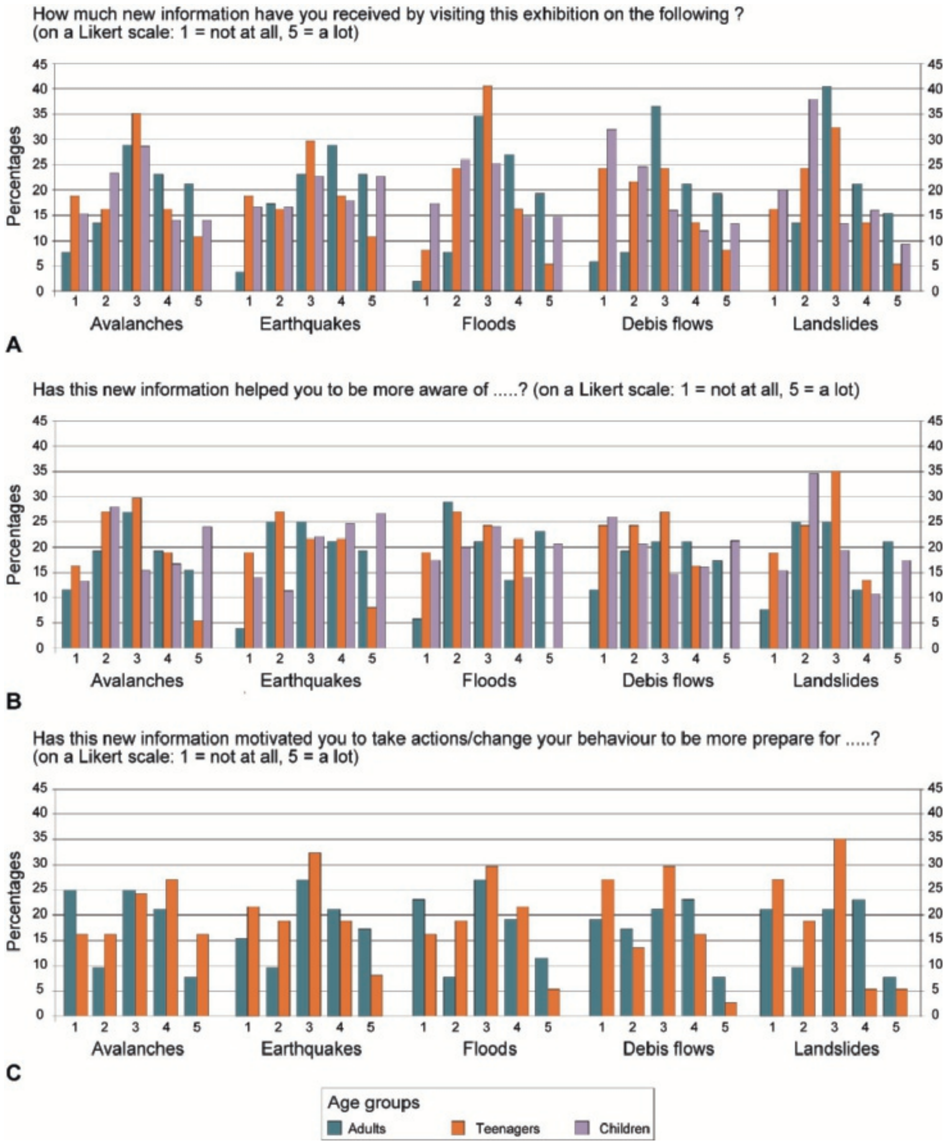


Figure A7.3: New Information received by visiting the exhibition and its reported impact on awareness and motivation to become prepared. Percentage for each score.

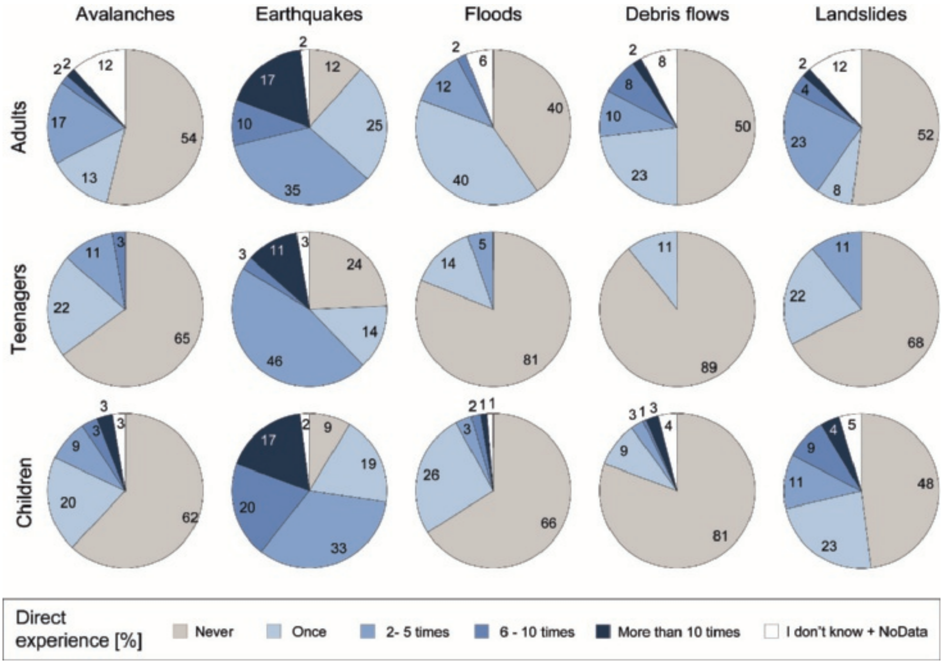


Figure A7.4: Direct experience with the specific natural hazards in percentages. Question: “How often have you experienced the following natural hazards (avalanche/earthquakes/floods/debris/landslides?”

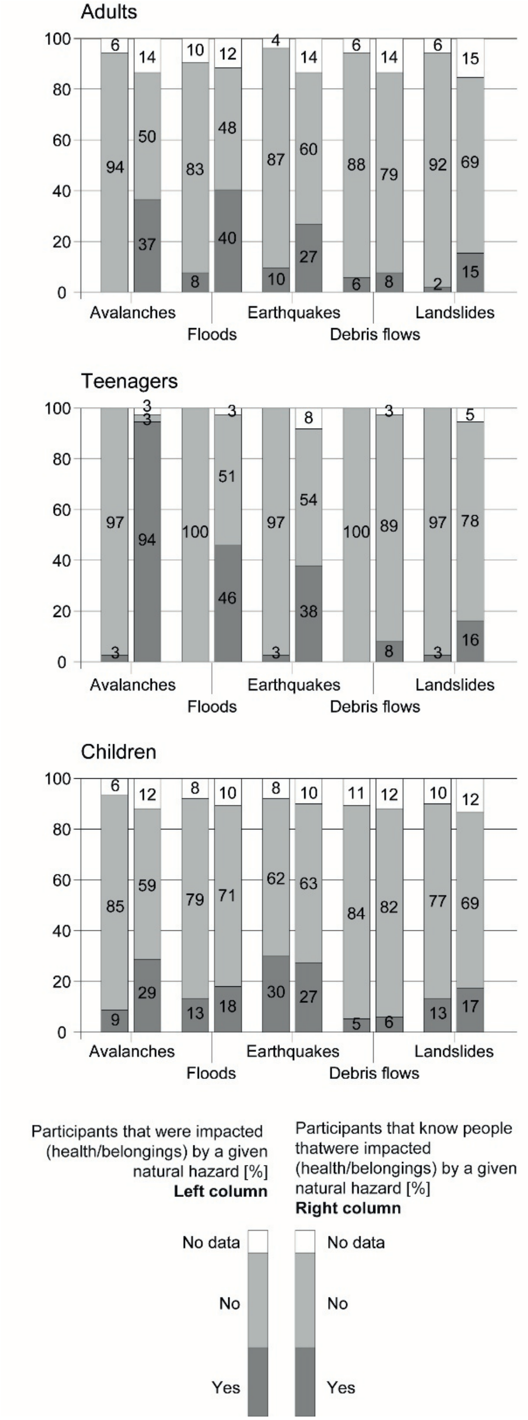


Figure A7.5: Own damage (physical/to belongings) and damages of acquaintances (physical/to belongings). Percentages by natural hazard. Questions: "Have you ever experienced health problems or suffered damages as a result of the occurrence of any of these natural hazards (avalanches/floods/earthquakes/debris flows/landslides)?" and "Do you know somebody that has experienced health problems or suffered damage of the occurrence of these natural hazards (avalanches/floods/earthquakes/debris flows/landslides)?"

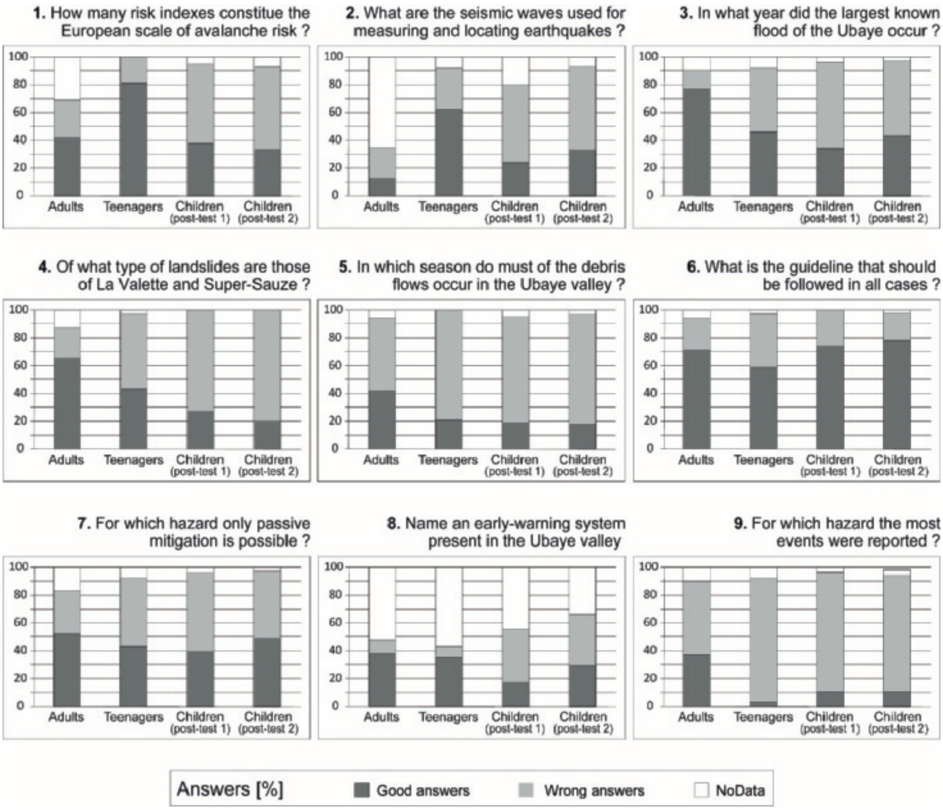


Figure A7.6: Results of the hard knowledge questions in percentages for all post-tests (adults, teenagers, children's post-test 1 and children's post-test 2).

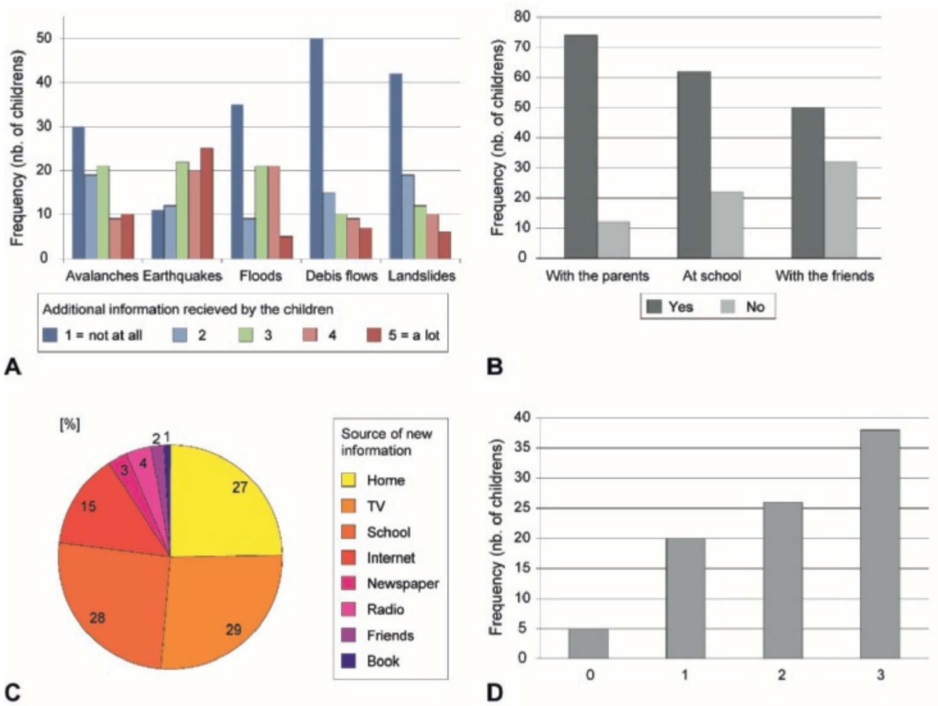


Figure A7.7: A-top) Additional information received related to the different hazards by the children (N=91) in between the two post-tests. Scores correspond to a Likert scale (1=none to 5=enormously). Question "Since the visit of the exhibition, how much new information have you received on avalanches/earthquakes/floods/debris flows/landslides?" A-bottom) Number of times the sources of this new information was mentioned by the participants. Open question: "how did you receive this information?". B-top) Number of children that discuss the topic of natural hazard after visiting the exhibition with their parents, at schools or with their friends. B-bottom) Number of children that discuss the topic of natural hazards in none, one, two or three of the discussion settings. Both B graphs derived from the question "Since the visit of the exhibition, have you discussed about natural hazards?"

Table A7.1: Changes measured by the Wilcoxon signed-ranked test. N=sample size. M1 = median pre-test; M2= median post-test; Z= test result. All tests are based on negative ranks meaning that there are increases in scores between the two-tests. Significant changes are highlighted in light green for the small effects and in darker green for the medium effects.

			N	M1	M2	Z	p-value	Effect size (*r*)
General indicators								
Ability to mitigate/respond/prepare		Self-reported awareness	221	4	4	-2.03	0.04	-0.14
		Self-reported vulnerability	211	3	3	-2.69	0.01	-0.19
		Self-reported amount of knowledge and information	206	3	3	-3.09	0.00	-0.22
		Self-reported amount of resources	63	2	3	-1.83	0.07	
		Self-reported preparedness	211	3	3	-5.07	0.00	-0.35
Specific indicators								
Worry level		Floods	225	2	3	-2.62	0.01	-0.17
		Landslides	219	2	3	-0.05	0.96	
		Debris flows	212	2	2	-1.51	0.13	
		Earthquakes	220	3	3	-1.16	0.25	
		Avalanches	224	4	4	-0.66	0.51	
Attitude to risks	Perceived likelihood	Floods	205	3	3	-3.32	0.00	-0.23
		Landslides	214	3	3	-0.60	0.55	
		Debris flows	208	3	3	-1.90	0.06	
		Earthquakes	221	4	4	-0.38	0.71	
		Avalanches	212	4	5	-2.78	0.01	-0.19
	Perceived consequences	Floods	214	3	4	-5.29	0.00	-0.36
		Landslides	213	3	3	-1.01	0.31	
		Debris flows	209	3	3	-2.10	0.04	-0.15
		Earthquakes	216	4	4	-0.13	0.89	
		Avalanches	219	4	4	-2.71	0.01	-0.18

General indicators			Effect size (*r*)				
			Adults (pre-test/ post-test1)	Teenagers (pre-test/ post-test1)	Children (pre-test/ post-test1)	Children (post-test1/ post-test2)	Children (pre-test/ post-test2)
Ability to mitigate/respond/ prepare		Self-reported awareness	N=48, M1=4, M2=5 Z=-2.20, p<.05, r=-.22	N=35, M1=3, M2=3 Z=-2.27, p<.05, r=-.27	N=138, M1=4, M2=4 Z=-0.1	N=84, M2b=4, M3=4 Z=-0.32	N=87, M1b=4, M3=4 Z=-0.45
		Self-reported vulnerability	N=45, M1=3, M2=3 Z=-0.93	N=34, M1=3, M2=3 Z=-2.07, p<.05, r=-.25	N=132, M1=2, M2=3 Z=-1.89	N=81, M2b=3, M3=3 Z=-0.11	N=79, M1b=2, M3=3 Z=-1.75
		Self-reported preparedness	N=42, M1=2, M2=3 Z=-2.86, p<.005, r=-.31	N=32, M1=3, M2=3 Z=-1.76	N=137, M1=3, M2=4 Z=-3.99, p<.001, r=-.24	N=85, M2b=4, M3=4 N=-1.38	N=83, M1b=3, M3=4 Z=-3.41, p=.001, r=-.26
		Self-reported amount of know. and info.	N=44, M1=2.5, M2=3 Z=-2.95, p<.005, r=-.31	N=33, M1=3, M2=3 Z=-1.54	N=129, M1=3, M2=4 Z=-1.5	N=82, M2b=4, M3=4 Z=-0.35	N=79, M1b=3, M3=4 Z=-2.27
Worry Level		Floods	N=45, M1=3, M2=3 Z=-0.32	N=37, M1=2, M2=2 Z=-2.01, p<.05, r=-.23	N=143, M1=2, M2=3 Z=-2.15, p<.05, r=-.13	N=86, M2b=3, M3=2 Z=-1.47	N=90, M1b=2, M3=2.5 Z=-0.72
Specific indicators							
Attitude to risks	Perceived likelihood	Floods	N=40, M1=3.5, M2=4 Z=-1.88	N=33, M1=3, M2=4 Z=-2.46, p<.05, r=-.30	N=132, M1=2, M2=3 Z=-1.99, p<.05, r=-.12	N=84, M2b=3, M3=2 Z=-3.43, p<.001, r=-.26	N=83, M1b=3, M3=2 Z=-2.05, p<.05r=-.16
		Avalanches	N=41, M1=5, M2=5 Z=-0.32	N=35, M1=5, M2=5 Z=-0.71	N=136, M1=4, M2=4 Z=-3.08 p<.005, r=-.19	N=89, M2b=4, M3=4 Z=-0.61	N=84, M1b=3.5, M3=4 Z=-1.41
	Perceived consequences	Floods	N=45, M1=4, M2=4 Z=-2.83, p<.005, r=-.30	N=34, M1=3, M2=4 Z=-3.67, p<.001, r=-.34	N=135, M1=3, M2=3 Z=-3.22, p<.001, r=-.2	N=83, M2b=3, M3=3 Z=-0.86	N=83, M1b=3, M3=3 Z=-1.39
		Debris flows	N=43, M1=3, M2=4 Z=-0.51	N=34, M1=3, M2=3 Z=-2.31, p<.05, r=-.45	N=132, M1=3, M2=3 Z=-1.47	N=81, M2b=3, M3=3 Z=-0.61	N=79, M1b=3, M3=3 Z=-0.37
		Avalanches	N=44, M1=3, M2=4 Z=-1.04	N=36, M1=4, M2=4.5 Z=-2.88, p<.005, r=-.28	N=139, M1=3, M2=4 Z=-1.44	N=86, M2b=4, M3=4 Z=-0.07	N=83, M1b=3, M3=3 Z=-0.19

Table A7.2 Changes by age group measured by the Wilcoxon signed-ranked test for the indicators that showed statistically significant changes. N=sample size. M1 = median pre-test; M2= median post-test; M3= median second post-test; M1b = median pre-test when compared to second post-test; M2b = post-test when compared to second post-test; Z= z-score, p = p-value; r = size effect; colored data = significant results; Green color = analysis based on negative ranks, i.e. it shows an increase between the two considered tests; orange color = analysis based on positive ranks, i.e. it shows a decrease between the two considered tests. Small effect size in light hues and for the medium effects in darker hues.

Table A7.3: Changes in awareness for the adult group by explaining variables measured by the Wilcoxon signed-ranked test. N= sample size, Z= z-score, p = p-value; r = size effect; colored data = significant results. The three hues from light to dark correspond respectively to small, medium and large effect size. All measured changes were based on negative ranks, i.e. it shows an increase between the two considered tests.

ADULTS - *Effect size (r)*	**Self-reported awareness**	**Self-reported preparedness**	**Self-reported amount of know. and info.**	**Perceived severity of the consequences of floods**
Gender	Men: N=23, Z=-2.39, p<.05, r=-.35	Women: N=21, Z=-2.68, p<.05, r=-.41	Women: N=23, Z=-2,82, p<.005, r=-.42	Women: N=24, Z=-2,14 p<.05, r=-.31
Age	-	51-70 years old: N=18, Z=-2.07, p<.05, r=-.35	-	>70 years old: N=19, -2,14, p<.05, r=-.35
Work related to natural hazards	-	No: N=26, Z=-2.95, p<.001, r=-.41	No: N=29, Z=-2.41, p<.05, r=-.32	No: N=29, Z=-2.36, p<.05, r=-.31
Time living in the valley	-	Not: N=6, Z=-2.24, p<.05, r=-.65	-	More than 20 years: N=26, Z=-2,36, p<.05, r=-.33 Not: N=6, Z=-2,24, p<.05, r=-.65
Last obtained degree	-	Unknown: N=14, Z=-2.23 p<.05, r=-.42	-	Level II: N=6, Z=-2.00 p<.05, r=-.58 Level V: N=6, Z=-2,12 p<.05, r=-.61 Unknown: N=17, Z=-2,12 p<.05, r=-.51
Number of experienced natural hazards*	2: N=8, Z=-2.07, p<.05, r=-.52	1: N=8, Z=-2.06, p<.05, r=-.52 2: N=8, Z=-2.06 p<.05, r=-.52	2:8, N= -2,12 p<.05, r=-.53	Yes: 16, Z=-2,50 p<.05, r=-.44
Suffered damages from the given number of natural hazards*	0: N=39, Z=-2.49 p=.01, r=-.28	0: N=33, Z=-3.46 p<.001, r=-.43	0: N=35, Z=-2.65 p<.01, r=-.32	No: N=42, Z=-2.92 p<.01, r=-.32
Knows people that suffered damages from the given number of natural hazards*	-	0: N=14, Z=-2.39 p<.05, r=-.45	0: N=17, Z=-2.17, p<.05, r=-.37	Yes: N=19, Z=-2.18, p<.05, r=-.35
Prior total information**	2: N=11, Z=-2.06 p<.05, r=-.44	1: N=7, Z=-2.23, p<.05, r=-.6 2: N=10, Z=-2.24 p<.05, r=-.6	1: N=7, Z= -2.05 p<.05, r=-.55 2: N=10, Z=-2.07 p<.05, r=-.46	1: N=14, Z=-2.53, p<.05, r=-.68

* These variables are used differently depending if general or specific indicators are analysed. In the first case, they become "Number of hazard types, among the 5 possible, experienced", "Number of hazard types, among the 5 possible, that impacted health and properties" and "Number of hazard types, among the 5 possible, for which they know somebody that was impacted". In the second case, i.e. in relation to floods' consequences perception, they were transformed in dichotomous yes/no variables: "floods experienced or not", "Impacted by floods or not" and "Know somebody impacted by floods".

** This variable is modified when used to analysed general indicators. Likert scales scores (1 to 5) for each of the natural hazards are summed and subsequently categorized in 5 prior information levels (1 to 5 -> 1, 6-10 -> 2, 11-15 -> 3, 16-20 -> 4 and 21-25 ->5). This variable is raw, i.e. "prior amount of information received on floods" when used for analyzing the specific indicator.

Table A7.4: Changes in awareness for the teenagers group by explaining variables measured by the Wilcoxon signed-ranked test. N= sample size, Z= z-score, p = p-value; r = size effect; colored data = significant results. The three hues from light to dark correspond respectively to small, medium and large effect size. All measured changes were based on negative ranks, i.e. it shows an increase between the two considered tests.

TEENAGERS *Effect size (r)*	**Self-reported awareness**	**Self-reported vulnerability**	**Worry level related to floods**	**Perceived likelihood of floods**	**Perceived severity of the consequences of floods**	**Perceived severity of the consequences of debris flows**	**Perceived severity of the consequences of avalanches**
Gender	Girls: N=16, Z=-1.97, p<.05, r=-.35	-	-	-	Boys: N=19, Z= -2.55, p<.05, r=-.41 Girls: N=15, Z=-2.66, p<.05, r=-.49	Boys: N=17, Z=-2.12, p<.05, r=-.36	Boys: N=19, Z= -2.14, p<.05, r=-.35
Work related to natural hazards	No: N=28, Z= -2.37 p<.05, r=-.32	-	-	-	No: N=28, Z=-3.45 p=.001, r=-.46	No: N=28, Z=-2.00 p<.05, r=-.27	No: N=30, Z=-2.60 p<.01, r=-.34
Time living in the valley	Not: N=13, Z=-2.27 p<.05, r=-.45	-	-	-	11-20 years: N=16, Z=-2.28, p<.05, r=-.40 Not: N=12, Z=-2.64 p<.01, r=-.54	11-20 years: N= 17, Z=-2,31, p<.05, r=-.40	-
Number of experienced natural hazards *	1: N=13, Z=-2.88, p<.005, r=-.56	-	-	No:N=27, Z=-2.32 p<.05, r=-.32	No: N=27, Z=-3.34 p=.001, r=-.45	No: N=31, Z=-2.31 p<.05, r=-.29	No: N=24, Z=-2.55 p<.05, r=-.37
Knows people that suffered damages from the given number of natural hazards*	-	-	No: N=19, Z=-2.23 p<.05, r=-.36	No: N=16, Z=-2.72 p<.01, r=-.48	No: N=19, Z=-3.14, p<.005, r=-.51 Yes: N=14, Z=-2.24 p<.05, r=-.42	No: N=31, Z=-2.00, p<.05, r=-.25	-
Prior total information*	-	-	-	-	1: N=11, Z=-2.27, p<.05, r=-.48	-	5; N=24, Z=-2.81, p=.005, r=-.41

The "age" variable was not considered as all teenagers fall in the same category (<18 years old). Similarly, "Suffered damages from the given number of natural hazards" is not considered as only one teenager had been impacted. Moreover, for obvious reasons, the "diploma" variable is not considered as well. Please refer to footnotes of table V for the explanation on how some variable were modified (*).

Table A7.5: Changes in awareness for the children group by explaining variables measured by the Wilcoxon signed-ranked test. N= sample size, Z= z-score, p = p-value; r = size effect; colored data = significant results. The three hues from light to dark correspond respectively to small, medium and large effect size. All measured changes were based on negative ranks, i.e. it shows an increase between the two considered tests.

CHILDREN *Effect size (r)*	**Self-reported preparedness**	**Worry level related to floods**	**Perceived likelihood of floods**	**Perceived severity of the consequences of floods**	**Perceived likelihood of avalanches**
Gender	Boys: N=75, Z=-2.85, p<.005, r=-.23 Girls: N=62, Z=-2.80, p=.005, r=-.25	-	Girls: N=59, Z=-2.24, p<.05, r=-.21	Boys: N=76, Z=-2.22, p<.05, r=-.18 Girls: N=59, Z=-2.28, p<.05, r=-.21	Boys: N=77, Z=-2.39, p<.05, r=-.20 Girls: N= 59, Z=-1.98, p<.05, r=-.18
Age	8 years old: N=36, Z=-3.43, p=.001, r=-.40	10 years old: N=43, Z= -2,07, p<.05, r=-.22	-	7 years old: N=15, Z=-2.49, p<.05, r=-.45 8 years old: N=34, Z=-2.55, p<.05, r=-.31	7 years old: N=16, Z=-2.55, p<.05, r=-.45 9 years old: N=38, Z=-2.28, p<.05, r=-.26
Time living in the valley	Since born: N=86, Z=-2.32, p<.05, r=-.18 1-5 years: N=36, Z=-2.83, p=.005, r=-.33	-	1-5 years: N=33, Z=-2.2, p<.05, r=-.27	Since born: N=91, Z=-3.79, p=.000, r=-.28	Since born: N=90, Z=-2.41, p<.05, r=-.18
Number of experienced natural hazards *	No: N=9, Z=-2.21 p<.05, r=-.52 1: N=32, Z=-2.46, p<.05, r=-.31	No: N=95, Z=-2.02 p<.05, r=-.15	No: 89, Z=-1.99 p<.05, r=-.15	Yes: N=45, Z=-3.64, p=.000, r=-.38	No: N=84, Z=-3.54, p=.000, r=-.27
Suffered damages from the given number of natural hazards*	0: N=78, Z=-3.86, p=.000, r=-.31 2: N=9, Z=-2.26, p<.05, r=-.53	No: N=112, Z=-2.32, p<.05, r=-.16	No: N=103, Z=-2.28, p<.05, r=-.16	Yes: N=19, Z=-3.14, p<.005, r=-.51	No: N=114, Z=-2.96, p<.005, r=-.20
Knows people that suffered damages from the given number of natural hazards*	0: N=66, Z=-3.05, p<.005, r=-.27	No: N=102, Z=-2.88 p<.005, r=-.20	No: N=91, Z=-2.15, p<.05, r=-.16	No: N=94, Z=-1.97, p<.05, r=-.14 Yes: N=27, Z=-2.24, p<.05, r=-.30	No: N=78, Z=-2.60, p<.01, r=-.21
Prior total information*	3: N=61, Z=-2.71. p<.01, r=-.25 5: -.44	-	2: N=30, Z=-.,01, p<.05, r=-.26	2: N=35, Z=-2.98 p<.005, r=-.36	5: N=39, Z=-2.68, p<.01, r=-.30

For obvious reasons, the "diploma" and "work related to natural hazards" variables are not considered. Please refer to footnotes of table V for the explanation on how some variable were modified (*).

Table A7.6: Longitudinal survey - Changes in awareness for the children group by explaining variables measured by the Wilcoxon signed-ranked test. N= sample size, Z= z-score, p = p-value; r = size effect; colored data = significant results. Green color = analysis based on negative ranks, i.e. it shows an increase between the two considered tests; orange color = analysis based on positive ranks, i.e. it shows a decrease between the two considered tests. Small effect size in light hues and for the medium effects in darker hues.

CHILDREN	Self-reported preparedness (pre-test/2nd post-test)	Perceived likelihood of floods (pre-test/2nd post-test)	Perceived likelihood of floods (1st post-test/2nd post-test)
Gender	Boys: N=43, Z=-2.70, p<.01, r=-.29 Girls: N=40, Z=-2.12, p<.05, r=-.24	Boys: N=42, Z=-2.27, p<.05, r=-.25	Boys: N=45, Z=-3.08, p<.005, r=-.32
Age	10 years old: N=26, Z=-2.06, p<.05, r=-.29	11 years old: N=5, Z=-2.0, p<.05, r=-.63	8 years old: N=27, Z=-2.56, p<.05, r=-.35
Time living in the valley	Since born: N=52 Z=-2.54, p<.05, r=-.25	-	Since born: N=53 Z=-2.65, p<.01, r=-.28 1-5 year: N=24 Z=-2.26, p<.05, r=-.33
Number of experienced natural hazards *	3: N=19, Z=-2.44, p<.05, r=-.40	-	No: N=57, Z=-3.17, P=.001, r=-.30
Suffered damages from the given number of natural hazards*	0: N=46, Z=-3.04 p<.01, r=-.32 2: N=7, Z=-2.04, p<.05, r=-.55	No: N=63, Z=-2.62, p<.01, r=-.23	No: N=67, Z=-3.24, P=.001, r=-.28
Knows people that suffered damages from the given number of natural hazards*	0: N=36, Z=2.88, p<.01, r=-.34	No: N=55, Z=-2.15, p<.05, r=-.20	No: N=56, Z=-2.42, p<.05, r=-.23 Yes: N=16, Z=-2.39, p<.05, r=-.42
Prior total information*	3: N=41, Z=-2.24, p<.05, r=-.25 5: N=12, Z=-2.05, p<.05, r=-.42	-	2: N=25, Z=-2.09, p<.05, r=-.30 4: N=9, Z=-2.06, p<.05, r=-.49 5: N=18, Z=-2.62, p<.01, r=-.44
Post total information*	2: N=24, Z=-2.3, p<.05, r=-.33	3: N=21, Z=-3.13, p<.005, r=-.48	3: N=29, Z: -2.82, p=.005, r=.37
Number of settings where natural hazard topic was discussed after the exhibition	1: N=20, Z=-2.2, p<.05, r=-.35 2: N=24, Z=-2.52, p<.05, r=-.36	-	2: N=23, Z=-2.01, p<.05, r=-.39 3: N=36, Z=-2.12, p<.05, r=-.25

* Please refer to footnotes of table VII for the explanation on how some variable were modified (*). "Post total information" is modified according to the same logic.

Acknowledgments

I would like to express my deep gratitude to all the people --and there are many-- that were walking besides me along the long path that led me to complete my PhD. Many thanks to all of them!

In particular, I would like to thank:

Prof.dr.ir. Nick van de Giesen, for welcoming me in the Water Resources Management group of the Civil Engineering Faculty of the TUDelft and allowing to pursue this research. I was glad to receive your very relevant feedback at each important steps of the process.

Dr. Thom Bogaard, for being the cornerstone of my PhD journey. I am extremely thankful for your supervision that was always useful and to the point! I enjoyed working with you a lot and particularly doing some “fieldwork” with you (especially in Naples!). You managed to know me very well and accompany me during the easy and not-so-easy times.

Dr. Erik Mostert, for teaching me so much. I appreciated a lot your very precise and patient supervision. You were able to ask the important questions at the right moments and my work has benefited a lot from your inputs. I am very also thankful for your help in navigating through Dutch culture and administration.

Dr. Sandra Junier, for completing this great supervision team. You were not obliged to get involved in my work. I am extremely very glad you did it as it certainly was positively influenced by you. Countless times you were the one that helped me stay the course. From this a great friendship evolved and I loved (and still do) discussing the joys and hazards of life with you.

The doctoral committee for the defense of this PhD thesis for their interesting comments and suggestions that helped me to improve the manuscript.

Prof. dr. Michel Jaboyedoff from the University of Lausanne for giving me the impulse to pursue further my education and for encouraging me to apply to a Changes Project PhD position. Thank you very much for allowing me to teach in your courses and welcoming me warmly every time I come back at the University of Lausanne.

Dr. Jean-Philippe Malet from EOST at the University of Strasbourg, for opening me the doors of the Ubaye Valley, supporting my work in this case study and teaching me how to be effective.

All the partners and stakeholders in France: the Médiathèque de Barcelonnette (and in particular Myriam Lèbre-Touquet, Josiane Rousset and Nadège Nicolas), the Barcelonnette municipality, the Services de Restauration des Terrains de Montagne (RTM), the Séolane Association, the Communauté de Communes Vallée de l'Ubaye, the Syndicat Mixte de Protection contre les Crues Ubaye-Ubayette, the Peloton de Gendarmerie de Haute Montagne de Jausiers, the Pompiers de Barcelonnette, the Équipe mobile académique de liaison et d'animation, the Association Nationale de l'Étude de la Neige et des Avalanches, the Centre National de la Recherche Scientifique (CNRS), the University of Strasbourg, the Jardin des Sciences of the University of Strasbourg, the Provence Alpes-Côte d'Azur Region, the Council of Europe, the European and Mediterranean Major Hazards Agreement, the Bureau Central Sismologique Français, the Réseau National de Surveillance Sismique, the European research project KULTURISK, the inhabitants of the Ubaye valley that provided material for the 'Alerte' exhibition (Valentine Allione, Pierre-Martin Charpenel, Jean-Pierre et Nicole Chevalier, Michel Isaïa, Michel Longeron, Émile Tron, Jacqueline Reynier, Madame Collomb and Madame Lequette) as well as all the participants to the study (the children and teenagers of the École primaire communale de Barcelonnette, de l'École Saint-Joseph, de l'École primaire de Saint-Paul-sur-Ubaye, du Collège André Honorat et de la Maison des Jeunes de Barcelonnettes and the adults of the Club Culturel, the Sabenca, the CCAS-Sauze, the CCAS-Méolans and of the Parc du Mercantour.

All the partners and stakeholders in Romania: IGRAC - Institutul de Geografiee - Bucharest University, Nehoiu Primary School, Liceu Radu Vlădescu, Emergency Situation Inspectorate - I.S.U. Buzău Nehoiu Volunteer Service, Civil Protection Buzău, Red Cross Buzău.

The interviewees from the Smartphone apps communicating avalanche risk information Avalanche Canada, Utah Avalanche Center, Avalanche Forecasts, WSL-Institute for Snow and Avalanche Research SLF, Norwegian Avalanche Center and SnowSafe.

The students that helped me: Angélique Monnier from the University of Aix-Marseille for the support to build the 'Alerte' exhibition content as well as Sam Bom and Paul Koot from the TUDelft for the RFID data filtering and processing.

All my 'Changes' colleagues; Juliette, Tess and Kathrin for being my 'partners in crime' all along the project; Dr. Alexandre Remaître, Dr. Mihai Micu and Irina Cristal for helping me in the case studies; and all the other ESRs for the fun we had during the 'Changes' meetings! Special tribute to those who opened my heart and my soul to the wonders of 80s' music! :D ♫ I'll keep it shining everywhere I go ♫.

All my TUDelft colleagues; the so much helpful secretaries Betty Rothfusz and Lydia de Hoog, my offices mates, Martijn, Meng, Shervan, Cai, Ameneh, Juliette, Julian and my fellow PhDs Congli, Tianduowa, Anna and Yingrong.

My employers since I am back to Switzerland, especially Marina Cracco (EPFL) and Marc Choffet (ECA-Vaud), for providing me with favorable conditions and encouragements to finish this thesis.

Stéphanie and François, my library mates in the last months of finishing this thesis! We finally all made it!

Beatriz, Marcelo, Daniel, Fabricio, Konstantin and Jörn. Guys, you are the best! Without you my stay in the Netherlands would have, for sure, been much more dull and difficult. We had so much fun!

Alejandra, I am so happy I met you! May we share much more nice moments together.

Elta, for being one of my role model of perseverance and strength and for always being here for me with the best advices ever, even from far away.

Mélanie and Samuel, my friends from here and there, for bringing to my life, in the Netherlands and Switzerland, so much joy, passionate debates and warm arms.

My friends in Switzerland, and especially Anaïs, Lorienne and Martin, you were my always-here-for-me home-based irreplaceable pillars!

My family-in-law, for your presence and the never-ending encouragement.

My family, for your unconditional support and love, for always believing in me, advising me and cheering me up when needed.

Florian, there are no words to tell you how much I respect, admire and love you. I will forever be grateful to you for understanding the importance of letting me go abroad for such a long time and for waiting for me to come back.

Curriculum Vitae

Marie Katerina Madeleine Humair-Charrière

19 April 1986 Born in La Chaux-de-Fonds, Switzerland

Education

2011-2018	PhD candidate Water Resources Management, Civil Engineering and Geosciences Faculty, Delft University of Technology, the Netherlands European Commission's Marie Curie Actions – Initial Training Network "Changes" Thesis: The Effectiveness of Risk Communication to Raise Awareness of Natural Hazards
2008-2011	MSc in Environmental Geosciences University of Lausanne, Switzerland Subject area: Analysis, Monitoring and Representation of Natural Hazards Thesis: Granulometrical, Geological and Morphological Description of the Frank Slide Deposit (Alberta, Canada)
2005-2008	BSc in Geosciences and Environment University of Lausanne, Switzerland Subject area: Environmental Studies (Public Policies, Alpine Environment and Risks)
2004-2005	David Game College, London, United Kingdom
2001-2004	Blaise-Cendrars High School, La Chaux-de-Fonds, Switzerland

Professional Experience

Since Jan. 2017	Natural Hazards Prevention Officer Public Building Insurance of the Vaud County (ECA-Vaud), Pully, Switzerland
11.2015 - 12.2016	DRR Technical Advisor – Tech4DRR MOOC Deputy Manager Cooperation & Development Center (CODEV) Swiss Federal Institute of Technology in Lausanne (EPFL), Switzerland
Since 2012	Lecturer Participation to the MSc Course « Communication on Environmental Risks » University of Lausanne, Switzerland
2008-2010	Student-Assistant Institute of Geomatics and Risk Analysis (IGAR), University of Lausanne, Switzerland

Academic Experience

2015-2017	Co-Convener European Geosciences Union General Assembly, Vienna, Austria "Natural Hazards Education, Communications and Science-Policy-Practice Interface" Session (2015, 2016 and 2017) "Should early career scientists be judged by their publication record? A set of group debates" Session (2017) "Geoethics: theoretical and practical aspects from research integrity to relationships between geosciences and society" Session (2016) "Communication and Education in Geoscience: Practice, Research and Reflection" Session (2015)
2016	Speaker at "Exit stage left: Science Debate as Theatre" workshop EuroScience Open Forum 2016, Manchester, United Kingdom
Since July 2015	Chair of the Youth Scientists Club International Association for Promoting Geoethics
Since Nov. 2014	Member of the Board of Directors Online platform Climanosco
2007-2010	Council Member Faculty of Geosciences and Environment Council University of Lausanne, Switzerland
2007-2010	Executive Committee Member Faculty of Geosciences and Environment Students' Association (AEGE) University of Lausanne, Switzerland

List of Publications

Journal Papers

Charrière, M.K.M., Junier, S.J., Bogaard, T.A., Mostert, E., Malet, J.-P., and van de Giesen, N.C. 2017. The impact of an exhibition on risk awareness of the general public in mountainous areas. International Journal of Disaster Risk Reduction, 25, 36-59.

Charrière, M.K.M., and Bogaard, T. A. 2016. Smartphone applications for communicating avalanche risk information-a study on how they are developed and evaluated by their providers. Natural Hazards and Earth System Sciences, 16(5), 1175-1188.

Aye, Z. C., **Charrière, M.K.M** Olyazadeh, R., Derron, M. H., and Jaboyedoff, M. 2016. Evaluation of an open-source collaborative web-GIS prototype in risk management with students. Spatial Information Research, 24(3), 169-179.

Charrière, M.K.M, Humair, F., Froese, C., Jaboyedoff, M., Pedrazzini, A., and Longchamp, C. 2016. From the source area to the deposit: collapse, fragmentation and propagation of the Frank Slide. Geological Society of America Bulletin, 128(1-2), 332-351.

Cortes Arevalo, V. J., **Charrière, M.K.M**, Bossi, G., Frigerio, S., Schenato, L., Bogaard, T., Bianchizza, C., Pasuto, A., and Sterlacchini, S. 2014. Evaluating data quality collected by volunteers for first-level inspection of hydraulic structures in mountain catchments. Natural Hazards and Earth System Science, 14(10), 2681-2698Book

Charrière, M.K.M., Malet, J.-P., Bogaard, T.A., Junier, S., Mostert, E., and Remaître, A. 2013. ALERTE : Connaître les risques en montagne, c'est y être mieux préparé. Les Cahiers de Seolane, 3, Seloane Edition, Barcelonnette, France.

Book Chapter

Froese, C., Jaboyedoff, M., **Charrière, M.K.M.**, Humair, F., and Pedrazzini, A. 2012. Characterization and management of rockslide hazard at Turtle Mountain, Alberta, Canada. In: Clague, J. and Stead, D., Landslides: Types, Mechanisms and Modeling, Cambridge University Press.

Conference Papers

Nicolet, P., Choffet, M., Franciosi, G., and **Humair-Charrière, M.K.M**. 2017. Sinkhole risk analysis from the point of view of a public building insurance, the case of Vaud County. Karstprobleme in der Geotechnik 2017, 18th May 2017, Olten, Switzerland.

Aye, Z.C., **Charrière, M.K.M**, Olyazadeh, R., Derron, M.H., and Jaboyedoff, M. 2015. Evaluation of an open-source collaborative webGID prototype in risk management with students. Free and Open Source Softare for Geospatial FOSS4G Seoul 2015.

Charrière, M.K.M, Junier, S.J., Bogaard, T.A., Mostert, E., and Malet, J.-P. 2014. Testing the effectiveness of visual risk communication in reality. A research approach that is beneficial for both scientists and communities at risk. International Conference Analysis and Management of Changing Risks for Natural Hazards, 18-19 November 2014, Padova, Italy.

Jaboyedoff, M., **Charrière, M.K.M.**, Derron, M.-H., Nicolet, P., Sudmeier-Rieux, K. 2013. Postface : La gestion des risques naturels est une dynamique. In : Nicolet, O. Derron, M.-H. and Jaboyedoff, M. (eds.), Les dangers naturels en Suisse: pratiques et développements, Comptes rendus de la deuxième Journée de Rencontre sur les Dangers Naturels (Université de Lausanne, 18 fevrier 2011). Mémoire de la Société vaudoise des Sciences naturelles, 25 :1-472.

Charrière, M.K.M., Bogaard, T., Mostert, E. 2013. Disaster managers' perception of effective visual risk communication for general public. Proceedings of the 8th International Conference on Geo-Information for Disaster Management, 13-14 December 2012, Enschede, The Netherlands.

Charrière, M.K.M., Junier, S.J., Mostert, E., and Bogaard, T.A. 2012. Flood risk communication – Visualization tools and evaluations of effectiveness. Proceedings of the 2nd European Conference on FLOODrisk Management, November 20-22, 2012, Rotterdam, The Netherlands.

Longchamp, C., **Charrière, M.K.M.**, Derron, M.-H., and Jaboyedoff, M. 2011. Experiments on substratum roughness, grainsize and volume influence on the motion and spreading of rock avalanches. 64th Pan-American Geotechnical Conference, October 2-6, 2011, Toronto, Canada.

Humair, F., **Charrière, M.K.M.**, Pedrazzini, A., Güell i Pons, M., Volpi, M., Foresti, L., Jaboyedoff, M., Epard, J-L., and Froese, C. 2010. The Frank slide (Alberta, Canada): from the contributing factors to the processes of propagation. 63rd Canadian Geotechnical Conference & 6th Canadian Permafrost Conference, September 12-16, 2010, Calgary, Canada.

Reports

Moreno, F., Jaboyedoff, M., Pedrazzini, A., **Charrière, M.K.M.**, and Humair, F. 2011. Frank Slide and Turtle Mountain Early-Warning System Technical Tour Guidebook (NTS 82G). ERCB/AGS Information Series Report 139.

Tonini, M., Vega Orozco, C., **Charrière, M.K.M.**, and Tapia, R. 2010. Relation between disaster losses and environmental degradation in the Peruvian Amazon. Global Assessment Report on Disaster Risk Reduction 2011.

Conference Abstracts

Charrière, M.K.M. 2016. Une approche de recherche active en communication du risque visant à sensibiliser le grand public aux dangers naturels. ScienceComm '16, May 22-23, 2016, Grandson, Switzerland. Oral Presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., and Mostert, E. 2016. Exploring risk communication – results of a research project focused on effectiveness evaluation. European Geosciences Union, General Assembly 2016, April 27-22, Vienna. Oral presentation.

Charrière, M.K.M., de Pascale, F., Gomez Cantero, J., Hassan, T., Mukosi, N.C., and O'Brien, C. 2016. The Young Scientist Club of the International Association for Promoting Geoethics – Promoting geoethics among the young geoscientists community. European Geosciences Union, General Assembly 2016, April 27-22, Vienna. Poster presentation.

Bourqui, M., Bolduc, C., Charbonneau, P., **Charrière, M.K.M.**, Hill, D., Lopez, A., Loubet, E., Philippe, R., and Winter, B. 2016. Bringing climate sciences to the general public with the Climanosco initiative. European Geosciences Union, General Assembly 2016, April 27-22, Vienna. Poster presentation.

Bourqui, M., **Charrière, M.K.M.**, and Bolduc, C. 2016. Climate Literacy through Learning-by-Doing: Engaging Communities in the Production of Accessible Research-Based Information. American Geophysical Union Fall Meeting, December 12-16, San Francisco. Poster Presentation.

Bourqui, M., **Charrière, M.K.M.**, and Bolduc, C. 2016. Co-Producing Accessible Climate Knowledge: Case Study of a Scientific Challenge. American Geophysical Union Fall Meeting, December 12-16, San Francisco. Oral Presentation.

Charrière, M.K.M, and Bogaard, T. 2015. Effectiveness of communication in climate change and risk research: is the impact evaluated and where is it presented at scientific conferences? European Geosciences Union, General Assembly 2015, April 12-17, Vienna. Oral presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., and Mostert, E. 2015. Communicators' perspective on snow avalanche risk communication. European Geosciences Union, General Assembly 2015, April 12-17, Vienna. Poster presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. 2015. Conducting research in risk communication that is both beneficial for stakeholders and scientists. European Geosciences Union, General Assembly 2015, April 12-17, Vienna. Oral presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. 2015. One exhibition, many goals. Combining scientific research and risk communication. European Geosciences Union, General Assembly 2015, April 12-17, Vienna. Poster presentation.

Bourqui, M., Bolduc, C., Charbonneau, P., **Charrière, M.K.M.**, Hill, D., Lopez, A., Loubet, E., Philippe, R., and Winter, B. 2015. A bottom-up, scientist-based initiative for the communication of climate sciences with the general public. European Geosciences Union, General Assembly 2015, April 12-17, Vienna. Poster presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. 2014. One exhibition, many goals. A case study on how to combine scientific questions with stakeholder views on effective communication of risks. American Geophysical Union Fall Meeting, December 15-19, San Francisco. Poster Presentation.

Charrière, M.K.M., Bogaard, T., and Mostert, E. 2014. Communicators' perspective on snow avalanche risk communication. American Geophysical Union Fall Meeting, December 15-19, San Francisco. Poster Presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. 2014. Testing the impact of visual communication on natural risks' awareness through an exhibition. 23rd SRA-E Conference, June 16-18, Istanbul. Oral Presentation.

Charrière, M.K.M., Bogaard, T., Junier, S.J., Malet, J.P., and Mostert, E. 2014. Testing the impact of visual communication on natural risks' awareness through an exhibition. European Geosciences Union, General Assembly 2014, April 27 – Mai 02, Vienna. Poster presentation.

Charrière, M.K.M., Sprague, T., Bogaard, T., Greiving, S., Malet, J.P., and Mostert, E. 2013. Are mangers' and the general public's perceptions of risk communication needs in line? A French alpine valley case study. European Geosciences Union, General Assembly 2013, April 7-12, Vienna. Oral presentation.

Charrière, M.K.M., Bogaard, T., Malet, J.-P., and Mostert, E. 2013. Increasing awareness and preparedness by an exhibition and studying the effect of visuals. European Geosciences Union, General Assembly 2013, April 7-12, Vienna. Poster presentation.

Sprague, T., Prenger-Berninghoff, K., and **Charrière, M.K.M.**, 2013. Risk communication: the connection between assessment and management of changing risks. European Geosciences Union, General Assembly 2013, April 7-12, Vienna. Oral presentation.

Cortes, V. J., **Charrière, M.K.M.**,, Aye, Z.-C., Bossi, G., Viero, A., Frigerio, S., Schenato, L., Sterlacchini, S., Bogaard, T., and Pasuto, A. 2013. First level inspection by trained-volunteers of torrent control structures in mountainous catchments: Towards a quality-evaluation of data collected. European Geosciences Union, General Assembly 2013, April 7-12, Vienna. Poster presentation.

Longchamp, C., **Charrière, M.K.M.**, and Jaboyedoff, M. 2012. Analogue modelling of rock avalanches and structural analysis of the deposits. European Geosciences Union, General Assembly 2012, April 22-27, 2012, Vienna, Austria. Poster presentation.

Jaboyedoff, M., **Charrière, M.K.M.**, Derron, M.-H., Humair, F., Longchamp, C., Michoud, C., Pedrazzini A. 2011. A review of slope-failures structures and fabrics modelling with example of Sierre rock slide and rock avalanche. 2nd Conference on Slope Tectonics, September 6-10, 2011, Vienna, Austria. Oral presentation.

Charrière, M.K.M., Jaboyedoff, M., Pedrazzini, A., Volpi, M., and Froese, C. 2011. New insights on the Frank Slide's deposit (Alberta, Canada). European Geosciences Union, General Assembly 2011, April 3-8, 2011, Vienna, Austria. Poster presentation.

Charrière, M.K.M., Pedrazzini, A., Froese, C., Volpi, M., Jaboyedoff, M., and Kanevski, M. 2010. The characterization of the Frank slide deposit. European Geosciences Union, General Assembly 2010, May 2-7, 2010, Vienna, Austria. Poster presentation.Pons, M.G.I., **Charrière, M.K.M.**, Pedrazzini, A., Froese, C., and Jaboyedoff, M. 2010. PFC2D Analysis of Frank Slide rockfall deposit (Turtle Mountain, Canada). European Geosciences Union, General Assembly 2010, May 2-7, 2010, Vienna, Austria. Poster presentation.