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On the perceived usefulness of risk descriptions for decision-making in disaster risk management

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Abstract

Managing risk using an "all-hazards" and "whole of society"-approach involves extensive communication of risk descriptions among many stakeholders. In the present study we investigate how professionals working with disaster risk management in such contexts perceive the usefulness of different descriptions of risk. Empirical data from the Swedish disaster risk management system were used in an attempt to investigate the aspects of a risk description that affect its usefulness (as perceived by professionals). Thirty-three local municipal risk and vulnerability assessments (RVA documents) produced in the region of Scania in 2012 were analyzed in terms of six variables. The documents were then ranked by professionals based on their perceived usefulness for decision-making. Statistical analysis was conducted to identify any possible correlations between the overall ranking of the usefulness of the municipal RVA:s and each of the variables. We conclude that the way the likelihood and consequences of scenarios are described influence the perceived usefulness of a risk description. Furthermore, whether descriptions of scenarios are included in a risk description or not, and whether background information concerning the likelihood of scenarios are included also influence perceived usefulness of risk descriptions.

Keywords: description of risk, risk and vulnerability assessment, disaster risk management, risk communication, usefulness, decision-making

1. Introduction

Major crises and disasters pose a serious threat to societies around the world. In the past thirty years, the impact of disasters has increased significantly [1], while new risks are constantly being identified [2]. Moreover, "it is not just the nature of major risks that seems to be changing, but also the context within which they appear…" [1]. In particular, systemic risks, i.e. "…those risks that affect the systems on which society depends – health, transport, environment, telecommunications, etc." [1], are becoming more difficult to manage due, for example, to institutional fragmentation [3, 4] and increased interdependencies and interconnections [5]. In response to these challenges many countries have introduced "all-hazards approaches" employing a broadened perspective to risk with the emphasis on identifying connections between a multitude of hazards and risks, rather than considering them in isolation [6, 7]. Moreover, the trend is also to employ a "whole of government" or "whole of society" approach [8] in addressing these challenges, which means that a wide variety of stakeholders are involved in the efforts to manage risks. Such approaches have great potential since they can mobilize considerable resources and a diversity of expertise to collectively address the management of risk. However, they are also associated with significant challenges that must be dealt with. For example, the more stakeholders that are engaged in the effort of managing risk, the greater the need for communication and information sharing. Sharing information in complex bureaucracies is always associated with barriers [9], and unless measures are taken to reduce them, they could seriously affect the ability to manage risk.

The present paper addresses the issue of communication and information sharing in multi-stakeholder systems for disaster risk management. UNISDR defines disaster risk management as "The systematic process of using administrative directives, organizations, and operational skills and capacities to implement strategies, policies and improved coping capacities in order to lessen the adverse impacts of hazards and the possibility of disaster." [10]. A key driver for the implementation of disaster risk management is the Hyogo framework for action [11] which has been signed by 168 nations. By signing this document they have committed themselves to, among other things, developing the capacity to identify, assess and monitor disaster risk. One important form of information sharing in this context is the communication of risk descriptions, e.g. the results of risk assessments, to support decision-making concerning how to lessen the long-term consequences of disasters. Although supporting decision-making is an important purpose of risk descriptions [12, 13], they may also serve other purposes. For example, they could be used to identify alternative decisions [14] or serve as a means of fostering shared understanding between various stakeholders [15]. Nevertheless, the focus in the present study is on the extent to which they support the decision-making of professionals working with disaster risk reduction.

Many scholars have contributed to the area of risk assessment and decision-making. Several of the contributions have been normative, e.g. focusing on suggesting methods for how one *should* make decisions in uncertain situations. For example, classic decision theory [16, 17] deals with how to make decisions in uncertain situations. More recently, several authors have made suggestions on how to manage risk in situations involving great uncertainty [18-20]. In the present paper, however, we have chosen a descriptive rather than a normative perspective. Thus, we are interested in how people *actually* make decisions, rather than how they *should* make decisions. However, the present study does not focus on the decision per se, but instead on the effect that different types of risk

descriptions might have on decision-making. More precisely, we have investigated how the way in which the risk is described, i.e., how it is presented, influences the usefulness of the description for decision-making as perceived by professionals, i.e. those working with the management of risk and who will use the descriptions. The empirical data used in this study were taken from the Swedish disaster risk management system[1].

The paper is structured as follows. First, we provide a brief overview of previous relevant research in the area of communicating risk descriptions. Secondly, we provide a short description of the Swedish system for risk and vulnerability assessment (RVA), with particular emphasis on the communication of risk-related information by the RVA documents between the local, municipal level and the regional level. Thirdly, we introduce the theoretical concepts that are used in the paper. Fourthly, we present the research methods that were used. We then present the results, and the findings and limitations of this study are also discussed, together with some suggestions for future studies that would be interesting in light of our findings. Finally, the conclusions are presented.

2. Risk communication between professionals

Successful communication is one of the key aspects for managing disaster risk in context characterized by multiple stakeholders, high level of ambiguity, complexity and uncertainty [21, 22]. Risk communication research has to a great extent been focused on communication between professionals and the public, and less attention has been paid to communication between professionals [23, 24]. However, in order to understand how disaster risk management systems work, and how one can design them so as to avoid blocking the "informational arteries" [9, 25] we also need to investigate risk communication among professionals.

Important contributions to our understanding of risk communication between professionals have been made by Kramer [9] who studied communication among various governmental authorities prior to the terrorist attacks of 9/11. He finds several factors, psychological, social and institutional, that contributed to hampering the flow of risk information prior to the attacks and thereby led to a failure of those involved to "connect all the dots" [9]. Moreover, Bier [23] presents a review of state of the art concerning risk communication to decision-makers. Included is a section focusing on the format of risk communication, which is highly relevant to the present study since we investigate the effect of different forms of written communication. In a comprehensive interview study Thompson & Bloom [24] investigate risk communication between risk assessors and risk managers. Thompson and Bloom's study stands out among previous contributions since it is based on a relatively large number of interviews (forty-one persons) and it directly investigates risk management professional's opinions and perceptions concerning different forms of risk communication. They conclude that, for example, when communicating risk to support decision-making it is good to include a presentation of the broader context of the decision, descriptions of how uncertainties might influence the effectiveness of different risk management options as well as stakeholder perceptions of the risks.

[1] Although the system is called the crisis management system ("krishanteringssystemet" in Swedish) we focus only on the part of it that deals with risk management.

Other important contributions that do not directly deal with the form of risk descriptions but focus on other aspects relevant in professional communication of risk include Veland & Aven [12], who investigate how different risk perspectives might influence risk communication, and Johansen & Rausand [26], who focus on the importance of risk metrics in communication.

In our opinion, what seem to be lacking in the scientific literature on risk communication between professionals is empirical studies where the effect of different forms of risk communication is investigated. More precisely, how professionals working with disaster risk management perceive the usefulness of risk descriptions for decision-making. The present paper presents such a study. However, before describing the study in detail it is necessary to provide a brief description of the context in which the study was carried out.

3. The Swedish RVA system

The Swedish RVA system is one of the most important components of the Swedish disaster risk management system. It consists of three administrative levels: national (state departments and agencies), regional (county administrative boards and county councils) and local (municipalities). Authorities at all levels are obliged by Swedish law to conduct RVA:s [27, 28]. According to a Swedish Government Official Report [29], the primary purpose of RVA:s is to increase the consciousness and knowledge of those responsible for making decisions concerning risks and vulnerabilities, and to constitute the basis for the planning and implementation of measures that reduce risks and vulnerabilities. Thus, one important purpose of the documents is that they should be useful for decision-making in terms of providing support in choosing effective disaster risk reducing efforts. For example, the RVA system is supposed to generate comprehensive overviews of risks and vulnerabilities at all levels in society: local, regional and national [30]. The overviews should guide the nation's disaster risk management activities within the geographical area of interest in terms of prevention and mitigation, preparedness, training, supervision, follow-up and research.

Moreover, the system is based on the general idea that an analysis conducted at a lower administrative level should serve as a basis for the analysis carried out by the level above. For example, the RVA:s produced by local municipalities should serve as the basis for the analysis conducted by the regional county administrative board. Similarly, the RVA:s presented by the regional authorities are used as input in the national RVA. The Swedish system is thus highly dependent on the ability of various authorities to communicate descriptions of risk through RVA:s.

In the present study we used municipal RVA:s, i.e., the RVA:s performed at the lowest level of the Swedish RVA system. All RVA:s from the local municipals of Scania (thirty-three documents) produced in 2012 were included in the study.

4. Theoretical concepts

The issue addressed in this paper is how different ways of communicating descriptions of risk influence the usefulness of the description. As described in the introduction, there may be many objectives of communicating such descriptions. Here, however, we focus on the *perceived usefulness* for *decision-making* as expressed by professionals working with

risk management. We define perceived usefulness as *the degree to which a person believes that a specific risk description would enhance the basis for decision-making*. Our definition is a modification of Davis' [31] to suit the present context better. Thus, the perceived usefulness is not directly related to the decision per se, but rather to the process of constructing the basis for a decision. Although making decisions and constructing the basis for decisions are two different activities, there are, of course, many similarities.

In investigating the usefulness of risk descriptions we have employed a design perspective (see, for example, [30, 32-35]). Thus, we consider the descriptions of risk to be artifacts, i.e., they are created by humans with a purpose in mind (as opposed to being the result of natural processes), and they must therefore be studied in relation to that purpose when analyzing their usefulness. In the present study we assume that the descriptions of risk contribute to the overall purpose of managing disaster risk in a specific system by supplying one or more stakeholders with information that supports decision-making. This purpose seems reasonable, given that one important purpose of introducing "all-hazards/whole of society" approaches is to increase the ability to prioritize scarce resources for risk reduction [7]. In a multi-stakeholder system for disaster risk management, many professionals on various administrative levels are involved in developing descriptions of risk. These descriptions are shared between the stakeholders, sometimes with many others, and sometimes with only a few. Regardless of the numbers involved, the reason for sharing the descriptions, and sometimes the data on which the descriptions are based, is that no single stakeholder possesses the knowledge required to produce assessments of risk covering all the relevant areas and all relevant aspects of risk. The relevant areas can be expressed in terms of geographical area and in terms of functional area, i.e., power distribution, transportation, healthcare, etc., and the relevant aspects are related to what is being protected.

Risk is a fundamental concept in the present study. Although we do not study the concept per se, we investigate various stakeholders' *descriptions* of risk, which usually involve the use of some kind of risk measure. The concept of risk has been defined in many different ways (for an overview, see for example, [36-38]). Aven et al. [36] found that regarding the ontological status of risk, the suggested definitions can be divided into three categories:

(a) risk as a concept based on events, consequences and uncertainties,
(b) risk as a modeled, quantitative concept (reflecting the aleatory uncertainties), and
(c) risk measurements (risk descriptions).

For reasons similar to those presented by Abrahamsson and Tehler [30], we have chosen to use a definition from category (a) since these definitions are usually broader than the, often technical, definitions in categories (b) and (c). Many of the definitions from categories (b) and (c) assume, for example, that probabilities or frequencies are the only way of describing uncertainty (see, for example, [39, 40]). The definition used in the present paper is Aven's definition of risk, as described below [41].

Using this definition of risk allows us to describe the important concepts (in addition to the risk concept) that are used in the present paper. More precisely, according to this definition of risk the important building blocks of the concept are events/scenarios (A), consequences (C) and uncertainties (U). Since we are studying different stakeholders'

assessments of risk, it is also important to separate the *concept of risk* from the *description of risk*. What we can investigate in the documents studied here are descriptions of risk. The notation used for a risk description is C′, Q, K, where C′ is a description of consequences, Q a measure of uncertainty, and K is the background knowledge on which Q is based [42].

The variables used in the present study can be described based on Aven's framework, referred to above. Six variables are used to describe how a description of risk is communicated in an RVA document. The first variable is called *description of scenarios* and we denote it by the term $A_{Scenario}$, which is the term used by Aven [41] for events or scenarios, with the addition of the subscript "*Scenario*". $A_{Scenario}$ is a dichotomous variable that can assume one of the two states "yes" or "no". Thus, a particular risk description in a specific document either includes descriptions of scenarios or not. Not including a description means that the names of scenarios, i.e. "flood", "earthquake", etc., are the only aspect mentioned in a specific risk description. If descriptions of the scenarios are included, then there will be explanations of what "flood", for example, means in a specific case. The reason why we believe that descriptions of scenarios will influence people's perception of the usefulness of the risk description is that it helps them relate the information in the risk descriptions to aspects they are already familiar with. As Fisher points out, "Humans are essentially storytellers" [43], and in a risk description the scenarios are "the story". The more details are provided concerning the scenario in question, the easier it is for a person to relate it to something he or she is already familiar with. It simply becomes easier to judge the credibility of the claims made in the risk description since the scenarios allow that person to assess its *narrative coherence*, i.e., whether there are gaps in the logic of the scenario, and its *narrative fidelity*, i.e., whether the scenario appears credible, bearing in mind the knowledge and experience of the person in question [43]. The first hypothesis we tested is:

H1: Risk descriptions are perceived as more useful if they include scenario descriptions than if they do not.

This hypothesis (*H1*), and those presented below, all claim that there is a relationship between the independent and the dependent variable of interest. We will test the null hypothesis (*H0*), i.e. that there is no relationship between the variables, for each hypothesis to see if it is possible to reject it.

Another aspect of scenarios that we believe will influence the usefulness of a risk description is whether the description includes information related to how and why the specific scenarios that are included in the risk description were chosen. This type of information is reflected by a variable we call $A_{Background}$. It is a dichotomous variable that can assume the value "yes" or "no". The hypothesis we tested is:

H2: *Risk descriptions are perceived as more useful if they include background information for scenario descriptions than if they do not.*

The third variable is called *description of likelihood,* and is denoted $Q_{Likelihood}$. This variable represents how the likelihood that a scenario (provided that they are used) will occur is described. Based on previous studies of the current Swedish RVA system [30, 44-46] we have found that a suitable scale to describe $Q_{Likelihood}$ is an ordinal scale with five categories. The categories that $Q_{Likelihood}$ can assume are "Not included", "Qualitative description",

"Qualitative ranking scale", "Semi-quantitative ranking scale", and "Quantitative scale (probabilities or frequencies)". A more detailed scale could have been used, for example, one reflecting whether probabilities are interpreted as a relative frequency or as a measure of degree of belief (Bayesian perspective). However, such detailed classification is not suitable here since none of the RVA documents included in this study describe those aspects. Few of the documents employ probabilities, and when they do, it is very difficult to determine how the probabilities should be interpreted. The motivation for including $Q_{Likelihood}$ in the present study is that it influences *the type of information that can be communicated.* For example, if no description of likelihood is given in a document it is obviously impossible to communicate anything regarding the likelihood of various events/scenarios and their consequences. Even if a qualitative description of likelihood is included, it is not possible to communicate any order between the events and their consequences in terms of likelihood. The reason for this is that people show considerable variation in the interpretation of qualitative descriptions of likelihood (see, for example, [47-49]). Thus, even if one person believes that a "probable" event will occur more often than one that is "likely", others will not necessarily share this interpretation. However, a scale can be established that allows order among events and consequences to be communicated in terms of likelihood. The most basic type of scale found in the material studied here (RVA documents) is a scale with five categories, where each category is described using words such as "Highly unlikely", "Unlikely", etc. The key point is not the terms themselves (as they might still be interpreted differently by different people), it is the fact that descriptions of risk including information on the assessment of whether a specific event or consequence is more or less likely than another can be communicated using that scale. The difference between a qualitative ranking scale and a semi-quantitative ranking scale is that the categories in the semi-quantitative ranking scale include numerical descriptions in terms of frequencies or probabilities, e.g. "Very likely, once every ten years". Such numerical measures are not included in the categories of a qualitative ranking scale.

Depending on how the likelihood of events and consequences are expressed, it is thus possible to communicate different aspects that can be used in different ways. In fact, the information that is communicated can be used in the same way as different types of measurement scales. Stevens [50] describes the four basic scales of measurement: nominal, ordinal, interval and ratio. Using a nominal scale allows the communication of equality, which means that one can describe two (or more) events or consequences as being equally likely. The ordinal scale allows the communication of greater or less, which means that it is possible to say that one event or consequence is more or less likely than another. The interval scale allows the communication of equality of differences, which means that one can say that the difference in terms of likelihood between two events or consequences is the same as the difference between two other events or consequences. Finally, the ratio scale allows the communication of equality of ratios, which means that one can say, for example, that the ratio between the likelihood of events A and B is the same as the ratio between the likelihood of events C and D. In the same sense as the measurement scales can be used to perform different operations (determination of equality, etc.) $Q_{Likelihood}$ reflects what can be communicated in terms of equality of likelihood, greater or less likelihood, equality of the interval between likelihoods and the equality of ratios between likelihoods. Therefore, we believe that people will perceive a risk description that

contains a semi-quantitative ranking scale, for example, to be more useful than one that only contains qualitative descriptions. Thus, the hypothesis that we tested is:

H3: Risk descriptions that allow more information concerning the likelihood of events and consequences in terms of determination of equality, determination of greater or less, determination of intervals or differences, determination of ratios, to be communicated are perceived as more useful than others.

Although descriptions of the likelihood of various events and consequences represents an important part of a risk description, other components related to likelihood are also important. In particular, the background knowledge on which the likelihood description is based might play a crucial role in determining whether the risk description is useful or not for a decision maker [51, 52]. Here we use the variable $K_{Likelihood}$ to represent whether a specific risk description contains an explanation of the assumptions on which the likelihood descriptions are based. This is also a dichotomous variable that can assume the states "yes" or "no". Admittedly, it is a rather crude way of classifying risk descriptions as there are many ways of expressing background knowledge that influence the usefulness of the risk description. Nevertheless, we find it difficult to achieve a high inter-coder reliability for more detailed ways of describing this variable (see Section 5.2), and we have therefore chosen not to use more states to represent this variable. The hypothesis that we tested is:

H4: Risk descriptions that include descriptions of background knowledge concerning estimated likelihoods are perceived as more useful than if they do not include such descriptions.

In addition to the two variables focusing on likelihood estimates ($Q_{Likelihood}$ and $K_{Likelihood}$) we included two similar variables that are related to the consequences. We call them $C'_{Consequences}$ and $K_{Consequences}$). The reasons why these two variables are likely to be important are the same as those presented above for $Q_{Likelihood}$ and $K_{Likelihood}$. The hypotheses we tested are:

H5: Risk descriptions that allow more information concerning the consequences in terms of the determination of equality, determination of greater or less, determination of intervals or differences, determination of ratios, to be communicated are perceived as more useful than others.

H6: Risk descriptions that include descriptions of background knowledge concerning estimated consequences are perceived as more useful than if they do not include such descriptions.

In conclusion, we used six variables to describe a specific risk description. Each variable is associated with a hypothesis concerning the usefulness of a risk description. Table 1 presents a summary of the variables and their possible states.

Table 1. The six variables and their possible states. Brackets ([ ]) are used to illustrate the possible states.

Variables	Possible states
$A_{Scenario}$	[Yes] or [No]
$A_{Background}$	[Yes] or [No]
$Q_{Likelihood}$	[(1) Not included], [(2) Qualitative description], [(3) Qualitative ranking scale], [(4) Semi-quantitative ranking scale], [(5) Quantitative scale (probabilities or frequencies)]
$K_{Likelihood}$	[Yes] or [No]
$C'_{Consequences}$	[(1) Not included], [(2) Qualitative description], [(3) Qualitative ranking scale], [(4) Semi-quantitative ranking scale], [(5) Quantitative scale (probabilities or frequencies)]
$K_{Consequences}$	[Yes] or [No]

5. Method

5.1. Analysis and evaluation of municipal RVA:s

The empirical data set used in the present study is the result of a content analysis [53] of all thirty-three RVA documents submitted to the county administrative board of Scania by the local municipalities in 2012. Each of these RVA:s is between 30 and 155 pages long, including appendices. Two coders who read through these documents performed the content analysis, looking for sentences and sections of text containing descriptions of various aspects of risk descriptions that were deemed to be important for the usefulness of a risk description (see section 4). The coders used a coding scheme [53] developed in a previous study [30]. The coding scheme contains many more variables than the ones of interest here. However, only the results pertaining to the six variables of interest here were used in the present study. Questions pertaining to the variables guided the process of analysis and evaluation. They are presented in Table 2 below. Moreover, the two coders also coded all RVA documents produced by the local municipalities in the county of Stockholm (twenty-six documents). The coding of the analyses from the county of Stockholm were only used to calibrate the coders, i.e. to make sure that their assessments were similar, and to assess inter-coder reliability (see below).

Table 2. Questions used to guide the process of analysis and evaluation of the documents.

Variables	Questions
$A_{Scenario}$	*Are risk scenarios explicitly described?*
$A_{Background}$	*Is the process used to select scenarios described and are the selection motivated?*
$Q_{Likelihood}$	*In what way is the likelihood of a certain risk scenario assessed and presented?*
$K_{Likelihood}$	*Is there any background/motivation regarding the likelihood assessment?*
$C'_{Consequences}$	*Are the potential consequences of each scenario presented? What type of information is given?*
$K_{Consequences}$	*Is there any background/motivation regarding the consequence assessment?*

5.2. The inter-coder reliability

The thirty-three RVA:s from local municipalities in Scania were analyzed by one of two coders. Among these documentations, both coders analyzed five of them, as well as four of the ones from the county of Stockholm with the purpose to check the inter-coder reliability (more specifically "inter-coder agreement"; [54-56]). It corresponds to roughly 15% of the RVA:s from the two counties. Two different methods were used in our study: the percent agreement method (also called simple agreement, percentage of agreement, or crude agreement) and Krippendorff's alpha (α) coefficient [57]. The percent agreement is the percentage of all coding decisions made by the coders on which the coders agree. It is simple, intuitive and easy to calculate. However, this method also has some major weaknesses, the most important of which involves its failure to account for agreement that would occur simply by chance, especially when the overall sample size is relatively small [56]. In order to minimize the possible overestimating of the agreement between the coders, Krippendorff's Alpha (α) coefficient was also calculated, not only because it is suitable when the analysis performed by multiple coders, but also because it is appropriate in cases when the variables are described on different types of scales (nominal or ordinal).

In the literature, the criterion for good percentage agreement is 90% [56] and for Krippendorff's alpha (α) coefficient is of 70% [58]. The values that we obtained were 0,89 for the percent agreement (for all six variables) and between 0.78 and 0.99 for Krippendorff's alpha (α) coefficient, which means there was very good agreement between the two coders in our study. Therefore, the results of the content analysis can be considered to be sufficiently reliable.

5.3. Ranking of the risk description's usefulness

5.3.1. *The professionals*

The document analysis was followed by a workshop (half a day) held with representatives from the county administrative board of Scania, who are responsible for the region's RVA work. Written information was sent to the board, prior to the workshop, to provide some background information concerning the study, the purpose of ranking the RVA:s, and instructions for the ranking. The participants in the workshop use the RVA documents in their jobs and they were therefore familiar with the material beforehand. Moreover, they also met several times before the workshop when the ranking was conducted and discussed the task. All county administrative boards have the task of evaluating the RVA:s produced within their geographic area of responsibility and therefore the participants were familiar with assessing the material from different perspectives. During the workshop, six representatives from the county administrative board were asked to rank all the RVA:s produced by the local municipalities in Scania. The ranking was performed with respect to how useful these documents were perceived to be as a basis for decision making on the regional administrative level, i.e. when the regional RVA document is developed. Each RVA was read thoroughly by at least two participants to reduce individual variation in the rankings. The group discussions also served to reduce individual variation. The result was an overall ranking of the municipal RVA:s within the region, with respect to whether they contained useful descriptions of risk that could be used to serve as a basis for decisions and further develop a regional RVA.

5.3.2. The students

In addition to arranging the workshop with the professionals from the county administrative board we also arranged two workshops with students from the master's program in risk management and safety engineering at Lund University. The students were all close to the end of their education (they had less than a year before graduation). They were given the same task and almost the same information as the representatives from the county administrative board. The only difference was that the number of RVA:s the students used was less than number used in the county administrative board workshop. Since ten of the thirty-three RVA:s contained classified material they were excluded from the student workshops. However, the remaining twenty-three RVA:s were identical to the ones rated during the county administrative board workshop. Five students participated in the first workshop and five in the second.

5.4. Correlational analysis

The aim of this study was to explore the question of what constitutes a useful description of risk, from the county administrative board's perspective, based on the description of risk communicated by the municipal RVA documents. In order to identify variables that are of importance in the usability of the municipal RVA:s, particularly when used as input for the regional risk assessment, statistical analysis was conducted to identify any possible correlations between the overall rankings of municipal RVA:s and the six variables used in analyzing the thirty-three municipal RVA:s (twenty-three for the student groups). The software IBM SPSS Statistics and Spearman's rho [59] were used for statistical analysis (two-tailed test, $\alpha = 0{,}05$).

6. Results

Table 3 shows the results of the statistical analysis regarding correlations between the overall ranking of the county administrative board and the students, and the variables in Table 1.

Table 3. Results of the correlation analysis (Spearman rho, two-tailed test). Test results presented in bold are significant on α-level 0,01 and those presented in italics are significant on α-level 0,05.

Variables	County Administrative Board (n=33)	Student Group 1 (n=23)	Student Group 2 (n=23)
$A_{Scenario}$	*ρ = .42, p = .015*	ρ = .26, p = .223	*ρ = .50, p = .016*
$A_{Background}$	ρ = .12, p = .502	ρ = -.22, p = .303	ρ = .30, p = .158
$Q_{Likelihood}$	**ρ = .59, p < .001**	**ρ = .74, p < .001**	**ρ = .57, p = .004**
$K_{Likelihood}$	**ρ = .54, p = .001**	**ρ = .56, p = .006**	**ρ = .71, p < .001**
$C'_{Consequences}$	**ρ = .59, p < .001**	**ρ = .75, p < .001**	*ρ = .52, p = .012*
$K_{Consequences}$	ρ = .33, p = .058	*ρ = .45, p = .032*	**ρ = .54, p = .009**

The findings of our study indicate that there is a moderate correlation between $A_{Scenario}$ and the rank provided by the county administrative board. Although the results are statistically significant (α = 0,05) for the county administrative board it is not so for one of the student groups. Nevertheless, despite the fact that the results are somewhat ambiguous we still find that they support hypothesis *H1*, i.e. that the inclusion of scenario descriptions in risk descriptions leads to greater perceived usefulness. However, we cannot find support for hypothesis *H2*, i.e. that including background information concerning how scenarios were selected will lead to greater perceived usefulness.

Moreover, the findings also indicate that there is a relationship between the way in which information concerning the likelihood *(H3)* and consequences of events *(H5)* is presented in a risk description and the perceived usefulness of that risk description. The results are statistically significant (α = 0,05) for both variables ($Q_{Likelihood}$ and $C'_{Consequences}$) and for all groups (county administrative board and students). The strength of the correlations is moderate from the county administrative board workshop and student workshop 2, while the indicated correlation is slightly stronger from the student workshop 1.

Finally, the results supports hypothesis *H4*, i.e. they show that there is a relationship between the presence of background information concerning likelihood in a risk description and its perceived usefulness. The result is statistically significant (α = 0,05) for all groups. However, we did not find support for hypothesis *H6*, which is concerned with the presence of background information regarding consequences. Although the results from the student groups show a significant result in terms of that hypothesis, the results from the county administrative board are not statistically significant.

7. Discussion

The present study represents an attempt to investigate what professionals working in disaster risk management systems perceive as useful ways of communicating descriptions of risk. We believe that this is of the utmost importance as many countries have recently developed, or are developing, "all-hazards/whole of society" approaches that are considered essential to prevent and prepare for various disastrous events. Developing these systems also involves constructing different guidelines and regulations on how risk descriptions should be communicated between stakeholders. Our study contributes to the design of such a process by providing insights into what kind of risk descriptions are perceived as useful. However, it should be noted that "useful risk descriptions" are not a goal in themselves. Rather, they are a *means* of achieving the *goal* of less damage to the things that human beings value, which in this context of societal safety often refer to critical societal functions, life and health of the citizens and their basic requirements (see for example [60]). However, it is very difficult to investigate the effect of different risk descriptions on actual losses. It would, for example, be difficult to collect a sufficient amount of data because disasters do not happen very often, and it would be very difficult to account for all the contextual variables that might influence the occurrence and development of disasters. Therefore, we consider the approach taken in the present paper to be more practical to investigate the issues of interest. Obviously, the relevance of the present study rests on the assumption that if some risk descriptions are perceived as more useful than others, it will be more likely that these descriptions lead to good decisions to prepare for or prevent disasters, which will then be implemented and hopefully influence the actual outcome in a positive way. However, the appropriateness of that assumption must be tested in future research. For example, using a specific type of risk description might increase the likelihood of well-grounded risk management decisions even though the professionals might not consider them to be more useful than others. In the present context, i.e. when focusing on disaster risk management, we expect that including background information regarding consequence estimates should lead to an improved situation, although we could not detect any significant difference due to this variable in our study. The reason is that if background information is included it helps the decision maker to judge the credibility of the assumptions underlying the assessments. Moreover, describing the background information would be even more important in situations characterized by deep uncertainties (see discussion in [20]).

Other aspects of the present study that should be developed in future studies include the addition of more variables, the development of more refined scales for the variables, and the replication of the results in controlled experiments. The strengths of the present study are that (1) it involves professionals, i.e., people actually working in a disaster risk management system, and (2) real risk descriptions, i.e., the actual documents that are sent to different stakeholders with the aim of communicating risk. This affords the study a high degree of relevance, both in terms of the material used (the actual documents) and in terms of the people/individuals making the estimates. However, paradoxically, it is also a weakness, as it can be argued that the documents that we have used contain much more than descriptions of risk, and the assessment of their usefulness may thus be influenced by other factors. Moreover, since we did not have any control over the form of the documents, it was impossible to ensure that there was an even distribution between the states of the variables. If we had been able to control the material, as in a controlled experiment, we could have ensured that all possible states of the variables were equally

represented in the material assessed by the participants in the study. It would also have been possible to make the distinction between the different states of the variables clearer, and avoid ambiguous examples. For example, in the material we used, some documents were not easily classified according to the variables. It may be that in one part of the RVA, a particular variable, for example, $Q_{Likelihood}$, was expressed in a certain way, while in the rest of the document it could be expressed in another way. This is also the reason why it was important to investigate the inter-coder reliability in the present study. Such analysis would not be necessary in controlled experiments. Another aspect that should be included in future studies is the investigation of the effect of more aspects of the risk descriptions. For example, the descriptions of the knowledge on which the consequences and uncertainties are based (K) may take many forms and include many types of information (see, for example [41]). It is highly likely that the extent to which such information is included in a risk description, and the way in which it is presented, will influence the perception of the usefulness of that risk description. However, K was only represented by dichotomous variables in this study (either there is background information, or there is not). It would be interesting to use a more detailed description of the variables representing K in future studies.

Despite the many drawbacks of using real documents in a study such as the present one, we believe that the approach is justified as a first step in gaining a better understanding of what professionals perceive as a useful risk description. The most reasonable continuation of the present research seems to be to carry out controlled experiments in which the hypotheses are tested again to investigate whether it is possible to replicate the results. Such a study is presently being conducted.

8. Conclusions

We have conducted experiments with a group of six risk management professionals at a county administrative board in southern Sweden. They were asked to rank a set of thirty-three risk and vulnerability assessments from municipalities in their county, based on the perceived usefulness. We then analyzed the documents based on the risk descriptions they provided and tested six hypotheses concerning the usefulness of the risk descriptions. We also invited ten master students who were trained to be the professionals in the field of risk management and safety engineering to do the same task as the representatives from the county administrative board did.

Based on the results of our analysis, we conclude that the way in which estimates of the likelihood of events and consequences are described influence the perceived usefulness of a risk description. Similarly, the way in which estimates of consequences are described also influences the perceived usefulness of a risk description. More precisely, it seems as the more of the following operations that can be performed using the estimates of either likelihood or consequences, the greater the perceived usefulness: (1) determination of equality, (2) determination of greater or less, (3) determination of equality of intervals or differences, and (4) determination of equality of ratios. Furthermore, including background information in the estimates of likelihood in a risk description positively influences the perceived usefulness. Finally, we also found that including descriptions of scenarios appears to positively influence the perceived usefulness of the risk description. Although we were not able to find support for the importance of including background

information concerning consequence estimates and concerning the choice of scenarios, we still believe that these aspects are important in a risk description.

Despite the fact that the number of participants in this study was limited in that we only included professionals from one county administrative board, of which there are twenty-one in Sweden, we believe that the results are valid in a broader disaster risk management context.

9. References

[1] OECD. Emerging Risks in the 21st Century: An agenda for action. Paris.2003.

[2] World Economic Forum. Global Risks 2013 Eighth Edition. Geneva, Switzerland.2013. p. 14.

[3] Almklov PG, Antonsen S. The commoditization of societal safety. Journal of Contingencies and Crisis Management. 2010;18:132-44.

[4] de Bruijne M, van Eeten M. Systems that should have failed: Critical infrastructure protection in an institutionally fragmented environment. Journal of Contingencies and Crisis Management. 2007;15:18-29.

[5] OECD. Future Global Shocks - Improving Risk Governance. Organisation for Economic Co-Operation and Development, OECD.; 2011. p. 12.

[6] European Commission. Commission Staff Working Paper - Risk Assessment and Mapping Guidelines for Disaster Management. 2010. p. 4.

[7] Wyman O. Studies in risk management: Innovation in country risk management. Paris: Organisation for Economic Co-Operation and Development, OECD.; 2009. p. 7.

[8] Caudle SL, de Spiegeleire S. A New Generation of National Security Strategies: Early Findings from the Netherlands and the United Kingdom. Journal of Homeland Security & Emergency Management. 2010;7:1-22.

[9] Kramer RM. A failure to communicate: 9/11 and the tragedy of the informational commons. International Public Management Journal. 2005;8:397-416.

[10] UNISDR Terminology on Disaster Risk Reduction. 2009.

[11] UNISDR. 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). Geneva, Switzerland2007.

[12] Veland H, Aven T. Risk communication in the light of different risk perspectives. Reliability Engineering and System Safety. 2013;110:34-40.

[13] Abt E, Rodricks JV, Levy JI, Zeise L, Burke TA. Science and decisions: advancing risk assessment. Risk Analysis. 2010;30:1028-36.

[14] Goble R, Bier VM. Risk assessment can be a game-changing information technology--but too often it isn't. Risk Analysis. 2013;33:1942-51.

[15] Renn O. Four questions for risk communication: a response to Roger Kasperson. Journal of Risk Research. 2014;17:1277-81.

[16] Savage LJ. The Foundations of Statistics. New York: Wiley; 1954.

[17] Von Neumann J, & Morgenstern, O. Theory of Games and Economic Behaviour. second ed: Princeton University Press; 1947.

[18] Cox LA, Jr. Confronting deep uncertainties in risk analysis. Risk Analysis. 2012;32:1607-29.

[19] Karvetski CW, Lambert JH. Evaluating deep uncertainties in strategic priority-setting with an application to facility energy investments. Systems Engineering. 2012;15:483-93.

[20] Aven T. On How to Deal with Deep Uncertainties in a Risk Assessment and Management Context. Risk Analysis. 2013;33:2082-91.

[21] Hermans MA, Fox, T., & van Asselt, M. B. A. Handbook of Risk Theory Epistemology, Decision Theory, Ethics, and Social Implications of Risk. In: S. Roeser RH, P. Sandin, & M. Peterson, editor. Risk Governance: Springer Netherlands; 2012. p. 1093–117.
[22] van Asselt MBA, Renn O. Risk governance. Journal of Risk Research. 2011;14:431-49.
[23] Bier VM. On the state of the art: risk communication to decision-makers. Reliability Engineering & System Safety. 2001;71:151-7.
[24] Thompson KM, Bloom DL. Communication of risk assessment information to risk managers. Journal of Risk Research. 2000;3:334.
[25] The National Commission on Terrorist Attacks Upon the United States. The 9/11 Commission Report. New York.2004. p. 80.
[26] Johansen IL, Rausand M. Foundations and choice of risk metrics. Safety Science. 2014;62:386-99.
[27] SFS. Förordning om krisberedskap och höjd beredskap. Swedish Code of Statutes. 2006:942.
[28] SFS. Lagen om kommuners och landstings åtgärder inför och vid extraordinära händelser i fredstid och höjd beredskap. Swedish Code of Statutes. 2006:544.
[29] SOU. Krishantering och civilt försvar i kommuner och landsting. Swedish Government Official Reports(in Swedish). 2004:134.
[30] Abrahamsson M, Tehler H. Evaluating risk and vulnerability assessments: A study of the regional level in Sweden. International Journal of Emergency Management. 2013;9:80-1.
[31] Davis FD. Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology. MIS Quarterly. 1989;13:320.
[32] Cedergren A, Tehler H. Studying risk governance using a design perspective. Safety Science. 2014;68:89-98.
[33] Denyer D, Tranfield D, Van Aken JE. Developing design propositions through research synthesis. Organization Studies. 2008;29:393-413.
[34] Gregor S, Jones D. The Anatomy of a Design Theory. Journal of the Association for Information Systems. 2007;8:313-35.
[35] March ST, Smith GF. Design and natural science research on information technology. Decision Support Systems. 1995;15:251-66.
[36] Aven T, Renn O, Rosa EA. On the ontological status of the concept of risk. Safety Science. 2011;49:1074-9.
[37] Aven T, Renn O. On risk defined as an event where the outcome is uncertain. Journal of Risk Research. 2009;12:1-11.
[38] Haimes YY. On the complex definition of risk: A systems-based approach. Risk Analysis. 2009;29:1647-54.
[39] Ale BJM. Risk assessment practices in The Netherlands. Safety Science. 2002;40:105-26.
[40] Willis HH. Guiding resource allocations based on terrorism risk. Risk Analysis. 2007;27:597-606.
[41] Aven T. On how to define, understand and describe risk. Reliability Engineering and System Safety. 2010;95:623-31.
[42] Aven T. On the link between risk and exposure. Reliability Engineering and System Safety. 2012;106:191-9.
[43] Fisher W. Narrative rationality and the logic of scientific discourse. Argumentation. 1994;8:30.
[44] Hassel H, Abrahamsson M, Eriksson K, Petersen K, Tehler H. Approaches and challenges for Swedish public agencies in the performance of risk and vulnerability analyses. 2012. p. 5005-14.

[45] Månsson P, Tehler, H., Abrahamsson, M., & Hassel, H. On common terms with shared risks - Studying the communication of risk between the local and regional level in Sweden. SRAE2013. Trondheim, Norway2013.
[46] Tehler H, Brehmer B, Jensen E. Designing societal safety: A study of the Swedish crisis management system. 2012. p. 4239-48.
[47] Ruth B-M. How Probable is Probable? A Numerical Translation of Verbal Probability Expressions. Journal Of Forecasting. 1982;1:257-69.
[48] Budescu DV, Broomell S, Por HH. Improving communication of uncertainty in the reports of the intergovernmental panel on climate change. Psychological Science. 2009;20:299-308.
[49] Budescu DV, Wallsten TS. Consistency in interpretation of probabilistic phrases. Organizational Behavior and Human Decision Processes. 1985;36:391-405.
[50] Stevens SS. On the Theory of Scales of Measurement. Science. 1946;103:678.
[51] Aven T, Reniers G. How to define and interpret a probability in a risk and safety setting. Safety Science. 2013;51:223-31.
[52] Aven T. Selective critique of risk assessments with recommendations for improving methodology and practise. Reliability Engineering and System Safety. 2011;96:509-14.
[53] Weber RP. Basic Content Analysis Thousand Oaks California: SAGE.; 1990.
[54] Tinsley HE, Weiss DJ. Interrater reliability and agreement of subjective judgments. Journal of Counseling Psychology. 1975;22:358-76.
[55] Tinsley HEA, & Brown, S.D. (Eds.). . Handbook of Applied Multivariate Statistics and Mathematical Modeling. San Diego, CA: Academic Press. ; 2000.
[56] Lombard M, Snyder-Duch J, Bracken CC. Content Analysis in Mass Communication: Assessment and Reporting of Intercoder Reliability. Human Communication Research. 2002;28:587-604.
[57] Krippendorff K. Content analysis: An introduction to its methodology: Sage Publications (Beverly Hills); 1980.
[58] Krippendorff K. Reliability in Content Analysis. Human Communication Research. 2004;30:411-33.
[59] Gauthier TD. Detecting trends using Spearman's rank correlation coefficient. Environmental Forensics. 2001;2:359-62.
[60] Olsen OE, Kruke BI, Hovden J. Societal safety: Concept, borders and dilemmas. Journal of Contingencies and Crisis Management. 2007;15:69-79.

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