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Communicating Quantitative Risk Information

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ABSTRACT

People often seek quantitative risk information, but, at the same time, many have problems understanding risk messages that contain statistics and numbers. Common hurdles with comprehending such messages can be related to the risk message itself, the message sender, and the message receiver. In this chapter, we review literature indicating that some representations and formats of quantitative risk information are easier to understand than others. These representations provide an important tool for risk communicators. Second, we detail the ways in which the message sender, a risk communicator, may hinder effective communication. Third, we discuss receiver characteristics, including literacy and numeracy skills, which can affect how the message is comprehended. For each of these three classes, we give practical recommendations that may help risk communicators to effectively communicate quantitative risk information. We conclude with a discussion of quantitative risk information in relation to risk perception and provide future research directions.

COMMUNICATING QUANTITATIVE RISK INFORMATION

As Benjamin Franklin eloquently stated, "In this world nothing is certain except death and taxes" (Smyth, 1907). Uncertainty is part of our daily lives. Ironically, to the extent that we, as a society, have gained control over more and more diseases and hazards, our awareness of risk has increased. At the same time, our willingness to accept risk has declined (Wiedemann, 1993). In other words, as our lives become safer (as affirmed by the increase of life expectancy over time), we become more aware of the threats to our lives. Technological developments drive and amplify such concerns, making it possible to detect even the slightest abnormalities. As a result, people want to be provided with information about risks and uncertainties (Frewer et al., 2002), and risk communication plays an important role in modern life—up to the point that relatively trivial news, such as weather reports, now include probabilities (Gigerenzer, Swijtink et al., 1989; Gigerenzer, Hertwig, van den Broek, Fasolo, & Katsikopoulos, 2005).

In popular terms, risk often refers to an uncertain negative outcome or event, but it may also indicate the probability that such an event happens, or this probability multiplied by the perceived negative consequences of the event. Leiss (1996) defined risk communication as "the flow of information and risk evaluations back and forth between academic experts, regulatory practitioners, interest groups, and the general public" (p. 86). Risk communication can serve several functions. Most broadly, it can inform or persuade. A risk message can elicit outrage and action, or it can provide reassurance and peace of mind. Some risk communication focuses on the prevention of a risk, such as a medical screening, while other risk communication comprises a response, like after a natural disaster. Risk messages can cover a variety of topics, including natural hazards, accidents, risks associated with industrial technologies, insurance rates, and political events. These messages are communicated by corporations, federal institutions, the military, health practitioners and other experts in various domains, or journalists, to name only a few. Risk information can be exchanged interpersonally, in a family conversation (see Galvin & Grill, this volume) or in a doctor's office, or it can be expressed to many, on television, through public speeches, on the Internet, or in a mass mailing to the general public.

Traditionally, persuasion research has emphasized what type of evidence should be presented to make a message more persuasive, memorable, or vivid. The research has focused on the differences between narrative, qualitative evidence and statistical, quantitative evidence (Allen & Preiss, 1997; Baesler & Burgoon, 1994; Kazoleas, 1993; R. Kopfman, Smith, Ah Yun, & Hodges, 1998; Reinard, 1988; A. Reynolds & J. L. Reynolds, 2002). Quantitative evidence has been broadly defined as empirically quantifiable information about objects, persons, concepts, or phenomena (Church & Wilbanks, 1986; Kazoleas, 1993). Research on receiver understanding of quantitative risk information holds importance for communication scholars as well as anyone who communicates risks professionally and who faces the challenging task of presenting complicated risk information in a clear, understandable way.

Goals of risk communication include building trust, influencing policy, fulfilling legal obligations, denying responsibility, justifying past actions, or simply helping people to understand risks that they face (Weinstein, 1999). In this chapter, we concentrate on common obstacles to message comprehension when communicating quantitative risk information. These obstacles can be related to (1) the risk message, (2) the sender of the message, or (3) its receiver.

The Quantitative Risk Message

Quantitative risk messages, if used correctly, can provide precise and accurate descriptions of risks, explaining why some message receivers prefer numerical risk information (e.g., Hallowell, Statham, Murton, Green, & Richards, 1997; Mazur, Hickam, & Mazur, 1999). Quantitative information can assist message receivers to make informed decisions under uncertainty regarding their financial investments, insurance policies, or health and medical treatments, to name just a few domains in which people commonly form decisions under uncertainty. However, even though people often seek quantitative risk information, at the same time, many people have problems understanding risk messages that involve numbers (Gigerenzer, 2002; Gigerenzer, Gaissmaier, Kurz-Milcke, Schwartz, & Woloshin,2008 Hoffrage, Lindsey, Hertwig, & Gigerenzer, 2000; Lloyd, Hayes, London, Bell, & Naylor, 1999). Thus, communicating risks to the public and the public's understanding of these risk messages are not necessarily the same thing. Simply providing accurate quantitative risk information does not necessarily ensure that receivers understand the risk message. The following examples illustrate several hurdles that can obstruct the goal of communicating risks effectively.

Consider a 25-year-old man who receives the results of an HIV test from his doctor. The doctor tells him that the test is positive. He asks the doctor, "What does a positive test result mean? Does it mean that I have HIV?" The doctor is faced with the difficult task of explaining this test result to the patient so that the patient can make an informed decision about how to proceed. What does the doctor tell this patient? The doctor will likely say "yes;" this man has HIV (Casscells, Schoenberger, & Grayboys, 1978; Eddy, 1982; Gigerenzer, 2002). Yet, as we describe in detail later, the probability that this man has HIV could actually be quite low (Gigerenzer,Hoffrage, & Ebert, 1998).

Communicators commonly use quantitative risk information to alter attitudes and behavior concerning public hazards. For instance, quantitative risk information can be provided as evidence that performing a particular behavior is risky, which leads us to our second example. To deter people from talking on their cell phones while driving, a message might state that "You are 400% more likely to get into a car accident while talking on a cell phone." People are left with the question, "more likely than what?" As we will explain further, such statements are usually based on a comparison of events, or more precisely, a comparison of two ratios of events. In this example, the statistic compares the number of accidents caused by drivers who were using a cell phone while driving with the number of accidents caused by drivers who were not using a cell phone while driving. Of course, these numbers need to be controlled for driving time—thus, we have to deal with ratios and not only with numbers of accidents. These ratios pertain to a particular reference class, the who or the what to which a risk applies. In fact, according to the frequentist school (e.g., von Mises, 1939), a probability, and let us add a risk, cannot be defined unless a reference class is specified. In other words, the meaning of a probability or a risk depends upon the definition of the reference class, and often, misunderstandings about the meaning of a particular risk message can be attributed to confusion about the identity of the reference class (Gigerenzer & Edwards, 2003; Hoffrage & Hertwig, 2006).

BASIC CONCEPTS

Risk communicators—government officials, politicians, managers, bankers, brokers, doctors, epidemiologists, engineers, journalists, and many others—face several choices to make when communicating quantitative risks. The uncertainty of a patient's HIV status, the risk of driving while talking on a cell phone, and the uncertainty of a bioterrorism threat can all be expressed in terms of probabilities, percentages, or frequencies. When determining the probability of a negative event or outcome, as a first step, a risk communicator must begin by choosing a reference class. The reference class determines which numbers will be presented. For example, will the frequencies of plane crashes be computed per month, year, decade, air company, category of distance traveled, or plane size? When it comes to comparing accidents in air transportation and rail transportation, what should the denominator be—accidents per a certain number of passengers, total miles traveled, passenger-miles traveled, or a certain number of trips? These decisions may lead to different conclusions about which mode of transport seems more risky. Thus, by choosing what to count and within which class to count, the communicator greatly influences what numbers will result, how receivers will perceive the risk, and, ultimately, even what decisions people will make.

In a second, equally important step, risk communicators specify how the acquired numbers should be represented. Quantitative risks can be expressed in terms of probabilities or frequencies. Probability values range from 0 (an event will definitely not happen) to 1 (an event will definitely happen). In contrast, frequencies result from counting specific cases (e.g., fatal accidents, bankruptcies) within a specific reference class (e.g., a group of people, a sample of events, often coupled with restrictions concerning the time interval during which the counting has been done), leading to relative frequencies of observations in a class of events. Percentages can be found either when messages include probabilities (e.g., a firm's probability of becoming bankrupt within the next 5 years is 20%) or estimated (relative) frequencies (e.g., experts expect 20% of firms in this industry and country to become bankrupt within the next 5 years).

Moreover, these numbers can be communicated in words, orally or in written form, or they can be represented graphically, in a chart or in a diagram. Like the choice of a reference class, the choice of a representation format can influence the understanding and choices of the receiver (Edwards, Elwyn, & Gwyn, 1999; Gigerenzer & Edwards, 2003; Hoffrage et al., 2000; Paling, 2003; Sackett, 1996).

TYPES OF NUMERICAL REPRESENTATIONS

In this section, we elaborate upon the basic notion of a probability and base rate, and we demonstrate that it is much simpler to understand a risk message when it presents numbers as frequencies rather than probabilities. Fortunately, research indicates that common quantitative information is neither difficult nor time consuming to master, if messages present it in the right way (Hoffrage et al., 2000; Sedlmeier & Gigerenzer, 2001).

Probabilities

A probability is a numerical expression of the likelihood that a particular event will happen. Probability values can range from 0 (x will definitely not happen) to 1 (x will definitely happen) (Kolmogorov, 1956). Probabilities can be distinguished into prior probabilities and posterior probabilities. Prior probability (the base rate or prevalence) is the probability of an event before any new evidence. For example, the probability that a man will have side effects from a medication may be .03. HIV prevalence can also be expressed as prior probability; for example, the probability that a heterosexual man has HIV is .0001 (see Table 5.1). Posterior probability is the updated prior probability—a conditional probability that includes additional information. In the HIV example, the additional information involved a positive test result, and the prior probability of .0001 has to be updated accordingly. The posterior probability that a man who receives a positive result in a HIV test actually has HIV if he tests positive is about 50% (Gigerenzer et al.,, 1998). The doctor in the earlier example could have explained the patient's HIV test result in terms of this percentage. As illustrated in Figure 5.1, the prevalence of HIV infections (p(HIV)) in heterosexual males in Germany in 1988, aged 20 to 30 who did not belong to a high-risk group, was about 0.01% or 0.0001.[1] The HIV test has a high sensitivity: Among those who are infected, the test detects the infection in 99.9% (p(POS | HIV) = .999). Likewise, an HIV test rarely produces false alarms: If someone is not infected, the test yields a positive result in only 0.01% of such cases (p(POS | NO HIV) = .0001). The doctor could use these numbers to compute the critical probability, namely the probability that the man is infected given that he tested positively, by using the Bayes theorem (Gigerenzer & Hoffrage, 1995):

$$\text{PPV} = \frac{p(\text{HIV})\, p(\text{POS}|\text{HIV})}{p(\text{HIV})\, p(\text{POS}|\text{HIV}) + p(\text{NO HIV})\, p(\text{POS}|\text{NO HIV})} \quad (1)$$

The positive predictive value (PPV) of the test and, thus, the critical probability is about .5 or 50%. Note that the relevant probability is not almost 1, but equals the probability that you get "heads" when you toss an unbiased coin.

Frequencies

Research indicates that recipients understand a positive test result (and other conditional probabilities) much more easily when the message presents numbers in the form of frequencies instead of probabilities. Over their evolutionary history, humans learned from direct experience rather than from books with statistics—and, for animals, this kind of learning (compared to others, such as imitation or instruction) plays an even larger role in knowledge acquisition (Gigerenzer & Hoffrage, 1995). Consider a physician who observes, case by case, whether or not her patients have a new disease and whether the outcome of a test is positive or negative. Scholars refer to this process as natural sampling (Gigerenzer & Hoffrage, 1995, p. 686; Kleiter, 1994). In contrast, a researcher using systematic sampling in scientific research may conduct a study and select 100 people with disease and 100 without the disease. The difference is that, in natural sampling, the proportions of people who have and who do not have the disease are naturally observed; whereas, in systematic sampling, they are artificially fixed a priori (see also Hoffrage, Gigerenzer, Krauss, & Martignon, 2002). Aggregating the individual observations obtained by natural sampling results in natural frequencies (Gigerenzer & Hoffrage, 1995; Kleiter, 1994). Specifically, in a naturally sampled population, natural frequencies result from counting individuals according to their features (e.g., disease vs. no disease, positive test result vs. negative test result; see Brase, Cosmides, & Tooby, 1998). Note that an isolated number, such as 18 infected people who test positive, is not, by itself, a natural frequency; it only becomes one because of its relationship to other numbers that result from counting different cases within the same sample.

Going back to the man receiving his HIV test result, his doctor could use natural frequencies for a fictitious sample of, say, 10,000 men to explain what a positive result actually means (see Figure 5.1). The doctor could say, consider 10,000 men in the United States with the same HIV risk as you. Of these 10,000 men, 1 will be infected with HIV and test positive. Out of the 9,999 men who are not HIV positive, one will test positive also. Therefore, the chance that you have HIV, if you test positive, is 1 in 2. When presented in the form of frequencies, risk professionals as well as laypeople, are better able to realize the relative degree of certainty regarding conclusions that can be drawn from a possible test result (Casscells, Schoenberger, & Grayboys, 1978; Eddy, 1982; Gigerenzer, 2002; Gigerenzer et al., 1998).

Notably, it does not make a mathematical difference if message senders write statistics as probabilities, percentages, or frequencies as in Figure 5.1, but it does make a psychological difference (Hoffrage et al., 2000; Slovic, Monahan, & MacGregor, 2000). When message senders express statistics as natural frequencies, they improve statistical thinking. The computations with natural frequencies make it simpler to understand what a positive result actually means.

Risk Reduction

Information about relative risk concentrates on how two or more risks relate to each other or how a particular risk in one group compares to the same risk in another group (see Gigerenzer, 2002; Sackett, Haynes, Guyatt, & Tugwell, 1991). Risk communicators commonly use this type of information to highlight the risks of certain activities or life-styles (e.g., does living next to a nuclear power plant increase the risk of getting leukemia?), the effectiveness of diagnostic instruments (e.g., does participating in screening program reduce mortality?), or therapies (e.g., how useful is homeopathy?). In all these cases, researchers compare two or more groups of people to each other with respect to how often a defined outcome occurs. For example, when seeking information about the benefits of mammography screening with respect to the risk of dying from breast cancer, women can read in brochures that, for women over 40 years old, undergoing routine mammography screening may reduce their risk of dying from breast cancer within the next 10 years by 25% (see Kurzenhäuser, 2003; Kurzenhäuser & Hoffrage, in press). This number is a *relative risk reduction* (RRR), derived from a ratio. The proportion of breast cancer deaths among women who receive mammography screening can be divided by (i.e., expressed relative to) the proportion of deaths among women who do not receive mammograms.

$$\text{Relative Risk Reduction} = 1 - \frac{O_T/N_T}{O_C/N_C}$$

O_T and O_C refer to the number of critical outcomes within a defined time period in the treatment (participation in screening) and control group (no participation), respectively; in this example, the number of breast cancer deaths in the next 10 years. N_T and N_C represent the number of people in the treatment and in the control group, respectively. As we can observe from this formula, if the proportion of women dying of breast cancer in the treatment group is identical to that in the control group (and, hence, the two complements, namely the two survival rates, are also identical), then the relative risk reduction of the treatment is zero. Conversely, if the proportion of women dying of breast cancer in the treatment group is reduced to zero, then the relative risk reduction is 100%.

The relative risk reduction is based on a comparison of two different groups of women, but receivers could likely understand it better if interpreted hypothetically, that is, for the same group of people. In the case of 1,000 women, if none of the women receive mammography screening, four will die of breast cancer in the next 10 years. If all 1,000 undergo screening, three of those four who would die without the screening would still die. That is, for three of the four women, the screening would not prevent this outcome (see Figure 5.2). However, for one of those four women (25%), the screening would make the difference between life and death. Note that this proportion does not reveal how many women would have to have mammograms to prolong the life of one woman, even though it is based on and was derived from numbers that allow us to answer this question.

Alternatively, the benefits of mammography can be framed in terms of *absolute risk reduction* (ARR)—the proportion of women who die from breast cancer without undergoing mammography screening minus the proportion of those who die despite being screened:

$$\text{Absolute Risk Reduction} = \frac{O_C}{N_C} - \frac{O_T}{N_T}$$

When presented in the form of absolute risk reduction, the numbers differ. Screening reduces the proportion of women who die from breast cancer from 4 in 1,000 to 3 in 1,000, that is, it prevents the bad outcome for 1 in 1,000. The inverse of the absolute risk reduction is the *number needed to treat* (NNT) or, in this case, the number needed to screen, in order to save one life (within a specified time interval). In the present example, the expected number of women who would have to be screened so that one woman could benefit (i.e., only survive because she was screened) is 1,000.

The relative risk reduction (in the present example, 25%) looks more impressive than the absolute risk reduction (0.1%). Unfortunately, health organizations inform patients about the benefits of mammography screening almost exclusively in terms of the relative risk reduction (Kurzenhäuser, 2003; Kurzenhäuser & Lücking, 2004). Perhaps not surprisingly, people more likely prefer an intervention if it is advertised in terms of relative risk reduction than in absolute risk reduction (Bucher, Weinbacher, & Gyr, 1994; Gigerenzer, 2002; Heller, Sandars, Patterson, & McElduff, 2004; Sarfati, Howden-Chapman, Woodward, & Salmond, 1998; for a recent review, see A. K. Ghosh & K. Ghosh, 2005), and grant agencies are more likely to fund research on the effectiveness of interventions if the benefits of those interventions have been communicated in terms of relative rather than absolute risk reduction (Fahey, Griffiths, & Peters, 1995). Conversely, people make more rational decisions about whether or not to accept a particular medical treatment when message senders communicate risk reduction in absolute rather than relative terms (Hembroff, Holmes-Rovner, & Wills, 2004; however, see Sheridan, Pignone, & Lewis, 2003).

Importantly, both absolute and relative representations of the frequencies are mathematically correct. Yet, each representation suggests different amounts of benefit or harm, potentially elicits different expectations, and ultimately leads to different decisions (Hanoch, 2004). Some representations, like relative risk, typically do not specify the reference class or do not specify any base rate information regarding the reference class.

Reference Class

With any representation of risk information, the primary source of confusion for the message receiver is the reference class (Gigerenzer & Edwards, 2003). A reference class comprises the class of events to which a probability applies (von Mises, 1939). Therefore, a reference class needs to be chosen carefully. Even more importantly, messages should clearly state which reference class has been chosen. Each reference class gives the probability of a negative outcome a different meaning. For example, consider the claim that "smoking accounts for 30% of all cancer deaths." Person A may understand this message as, "of all people who will die of cancer, 30% will die of lung cancer." Person B may think, "of all people who will die of cancer, 30% are smokers." Person C may interpret it as, "of all people who die of cancer, 30% only die because they are smokers." Person D may understand the message as "30% of smokers will die of cancer." Finally, Person E may think that "30% of all people who have lung cancer will die from it." Persons A, B, and C's reference class encompasses all people who die of cancer; person D's reference class refers to people who smoke, and person E only considers people with lung cancer.

Gigerenzer et al. (2005) investigated how the public understands the quantitative probability of rain and demonstrated that different understandings correspond to different assumptions about which reference class is underlying meteorologists' probability statements. Pedestrians in five countries—the Netherlands, Greece, Germany, Italy, and the United States—were surveyed in public places. Participants were told, "there is a 30% chance of rain tomorrow." The people in these countries have different degrees of exposure to probabilistic weather forecasts. Results indicated that two-thirds of Americans understood the probability of rain as the meteorologists intended, "When the weather conditions are like today, in 3 out of 10 cases there will be rain the next day." However, only one-third to one-fifth of respondents in the Netherlands, Germany, Italy, and Greece interpreted the probability as it was intended. The most common interpretations in these countries were "It will rain tomorrow 30% of the time" and "It will rain tomorrow in 30% of the area." The authors suggested that confusion about the meaning of probabilities might stem from three common practices in the media. First, in some countries, like Greece, weather forecasts do not typically include probabilities. Second, when the media provides probabilities, they do not typically include the class of events to which they refer. Third, in the few cases when a message mentions a reference class, it is often the wrong reference class. Gigerenzer et al. advocated that a reference class should always be given when message senders provide probabilities. An important lesson can be learned from the smoking example and the weather probability study—the meaning of a probability hinges on the choice of the reference class.

MESSAGE FRAMING

In addition to the format of the numerical presentation and the specification of a reference class, other message characteristics can also influence risk perception. One type of framing effect suggests that people organize information in terms of potential gains or potential losses (Kahneman & Tversky, 1979, 1982; Tversky & Kahneman, 1981). Therefore, information can be presented in a way that encourages people to process it in terms of potential benefits or potential costs. A gain-frame message presents the benefits of adopting a particular behavior. For example, “if you take an HIV test, the disease can be detected early, and early detection, in turn, increases the number of treatment options that you have.” A loss frame message presents the costs of not adopting a particular behavior. For example, “if you do not have an HIV test, the disease cannot be detected early, and the lack of information decreases the number of treatment options you have if you are infected.”

Research indicates that people respond differently to information presented as a gain or presented as a loss. According to Salovey, Schneider, and Apanovitch (2002), loss frame messages encourage people to consider the negative consequences of the decision. Therefore, people are motivated to engage in a risky behavior if the behavior helps them to avoid a loss. Alternatively, gain-frame messages have the potential to make people feel less endangered. Therefore, they less likely perform a behavior with uncertain outcomes. These predictions contribute to prospect theory’s four-fold pattern, which states that for medium and for high probabilities, people are risk-seeking for losses and risk-averse for gains (Kahneman & Tversky, 1979). Thus, gain-frame messages more likely cause individuals to become adverse to risk; they do not want to do anything to jeopardize the gains presented in the message. As a consequence, if a message sender frames a health message in terms of a gain, and the risk is medium to high, people will not want to lose the benefit of treatment options and will be more likely to be tested. Based on this research, Paling (2003) recommended framing statistical information in both positive and negative terms.

O’Keefe and Jensen (2007) argued that, for some risk messages, the influence of framing may be quite small. O'Keefe and Jensen conducted a meta-analysis using 93 studies (N = 21,656), and they found that, for disease prevention messages, gain-framed appeals were statistically significantly more persuasive than loss-framed appeals. However, this difference was small ($r = .03$), and O’Keefe and Jensen asserted that this effect may be due to a large and statistically significant effect for messages advocating dental hygiene behaviors. They did not find statistically significant differences in persuasiveness between gain and loss-framed messages for other preventive behaviors, including safer-sex behaviors, skin cancer prevention behaviors, or diet and nutrition behaviors (also see O'Keefe & Jensen, 2008.

Message Format

In addition to selecting numbers and text, message senders also select a format for the message. Quantitative evidence can be presented in many different formats—spoken verbally, presented as written text, or presented visually with a graph or picture. The format of the message can affect comprehension and influence the quality of the risk communication (Civan, Doctor, & Wolf, 2005). Usually, doctors only give medical information verbally to patients. Quantities can be expressed verbally using labels like *rarely*, *occasionally*, and *frequently*. Fischer and Jungermann (1996) concluded that people interpret verbal labels differently depending on the context. If people interpret verbal expressions as representing frequencies that are higher or lower than reality, their interpretations could cause serious implications for health decisions and behavior. Fischer and Jungermann (1996) maintained that "numbers are better than words" (p. 170). In addition to the labels, people should be told what each verbal label means in numerical terms.

Thomson, Cunningham, and Hunt (2001) contended that giving information verbally is not always the best method to facilitate patient understanding and comprehension. Additionally, Kessels (2003) described the obstacles of written information for individuals with low education, low literacy, or individuals who speak a different native language than their doctor. Therefore, visual representations may be better than verbal or written information at times.

Various types of visual formats can present quantitative risk information, including pictures, bar graphs, histograms, pie charts, and pictographs. Each visual format has unique advantages. For example, bar graphs can show ungrouped frequency distributions, while histograms can illustrate continuous, grouped frequency data. Pie charts are good for showing part to whole relationships. In addition to these traditional formats, advances in technology allow for innovative formats with distinct advantages. Interactive multimedia, such as that found on Web pages or on CD-ROMS, requires active involvement of the user and can be adapted to the ability and characteristics of the message receiver (Strecher, Greenwood, Wang, & Dumont, 1999). In this volume, Noar, Harrington, and Aldrich discuss a new approach of tailoring persuasive messages at the individual level. Computer algorithms can create personalized messages based on an individual's characteristics.

Overall, the research exploring the effects of graphical representations is inconclusive, and it suggests that one representations format is not always superior. Specifically, visual representations are not always effective (Lipkus, 2007; Parrott, Silk, Dorgan, Condit, & Harris, 2005). Lipkus discussed the advantages and disadvantages of visual, graphical displays and suggested that graphical displays are able to summarize a lot of information and show patterns in the data (e.g., interaction effects, regression lines). Some numerical data may be overwhelming, and graphical displays can be used to change a numerical, computational task into a perceptual task for the message receiver. On the other hand, graphical displays may discourage people from considering details, like numbers. Also, individuals may lack the skills to interpret a graph, and graphs can be misleading by amplifying the effects of certain elements and diminishing the effects of others (Huff, 1954). Moreover, while visual formats may enhance the risk communication process, we know little about how these formats affect risk-related behaviors (Civan et al., 2005).

How Can Obstacles Related to the Risk Message Be Avoided?

We propose that risks should be communicated in terms of natural frequencies, rather than in terms of probabilities, to give people a better chance to realistically assess their magnitudes. At a minimum, both types of information should be provided (Edwards, Elwyn, & Gwyn, 1999; Gigerenzer & Edwards, 2003; Paling, 2003; Sackett, 1996). As Figure 5.1 illustrates, when message senders express statistics as frequencies, they facilitate understanding the meaning of new information; for instance, a result of a diagnostic test. In a study involving 48 physicians, Hoffrage and Gigerenzer (1998) provided base rate information and the statistics of the corresponding diagnostic tests. The physicians had, on average, 14 years of professional experience, with a range from one month to 30 years. They worked on four diagnostic problems in which they had to infer the presence of breast cancer from a positive mammography test, colorectal cancer from a positive hemoccult test, phenylketonuria from a positive Guthrie test, and Bekhterev's disease from a positive HL-Antigen-B27 test. When researchers presented the information in probabilities, the physicians correctly inferred the posterior probability that a patient with a positive test actually has the disease in only 10% of cases. In contrast, when the researchers shared the same information in natural frequencies, that percentage increased to 46%.

For relative risk representations, Heller et al. (2003) pointed out that relative risk measures do not consider the prevalence of a risk in a given population. These authors also asserted that communicating numbers that show the impact of a risk in a specific population make the information easier to calculate and understand. By providing the full information, both the absolute and the relative risks can be easily extracted. For instance, the risk of anthrax exposure can be communicated by explaining, according to the CDC, the chance that any one individual in the United States will contract anthrax in a given year is about one in 300 million people (Centers for Disease Control and Prevention, 2008). In 2001, with the intentional release of anthrax spores in some environments, the nationwide risk was about 23 in 300 million people. Communicated this way, people can realize that the risk has increased by a factor of 23, but they can also understand that the risk is still quite small, compared to fatal car accidents for instance.

With regard to visual format selection, the choice should depend upon the purpose of the risk communication. Some messages intend to enhance quantitative understanding or promote good judgments, while others strive to promote behavior change (Ancker, Senathirajah, Kukafka, & Starren, 2006). Parrott et al. (2005) maintained that graphical displays should be used with caution. A graph can have a considerable amount of face validity. Therefore, a graph may look like it makes sense, so a person may not look closely at the information within the visual. Parrott et al. determined that visual representations of data did not significantly enhance understanding of health risk, and the general public was less proficient in understanding data in this way. Given that health frameworks often consist of several components (e.g. genetics, personal behavior, and environment), it is difficult to include all relevant details in a single graph. Therefore, as Parrott et al. argued, individuals may have difficulty translating a visual form of quantitative evidence associated with one scientific study into something meaningful.

In addition, the choice of graphical representation may make a difference. For example, bar charts constitute one of the most widely used forms of conveying statistical information (Parrott et al., 2005). Receivers presumably have experience processing information presented in this way, and they probably also possess the skills needed to interpret such information. Graphically representing health risk information in other forms (e.g., stick figures, smiley faces) may take longer for people to understand because they must first educate themselves about how to interpret the information, before they are able to make it meaningful to themselves. Unfortunately, no best way exists to present risk information in all situations. The same format may not work with different audiences. Most importantly, the format needs to be appropriate for both the message content and the message receiver. Lipkus et al. (2001) called for more research on developing and testing useful formats for communicating risk.

The Message Communicator

We do not lack studies showing that the general population has problems processing quantitative information (e.g. Doyal, 2001; Lemaire, 2006; Lloyd, 2001; Schwartz, Woloshin, Black, & Welsh, 1997; Weinstein, 1989). Astonishingly, research shows that experts, including doctors and judges, often experience difficulties with understanding and calculating risks as well. Thus, one obstacle of successful risk communication is that even communicators have trouble grasping quantitative information at times (Barke, Jenkins-Smith, & Slovic, 1997).

Difficulties in Processing and Calculating Risk

In a classic study, Eddy (1982) asked physicians to estimate the probability that a woman has breast cancer, given that she has a positive mammogram. Eddy provided the following information: (1) the probability that a patient has breast cancer is 1%; (2) if the patient has breast cancer, the probability that the radiologist will classify the mammogram as positive is 79%; and (3), if the patient has a benign lesion (no breast cancer), the probability that the radiologist will still provide a positive test result is 9.6%. In this study, 95 of 100 physicians estimated the probability of breast cancer after a positive mammogram to be about 75%. The correct answer is 7.7%, considerably lower than most physicians concluded.

In a related study, faculty, staff, and students at Harvard Medical School were asked to estimate an individual's probability of having a disease (Casscells et al., 1978). The researchers told participants that, "if a test to detect a disease whose prevalence is 1/1000 has a false positive rate of 5%, what is the chance that a person found to have a positive result actually has the disease, assuming you know nothing about the person's symptoms or signs?" Only 11 out of the 60 participants gave the correct answer of 2%. Most of the participants estimated that the individual would have a 95% chance of having the disease.

Experts in other fields have problems drawing the correct inferences from conditional probabilities as well. In a study conducted in Germany, legal professionals who would soon qualify as judges and advanced law students were asked to evaluate two court cases involving rape (Hoffrage et al., 2000; Lindsey, Hertwig, & Gigerenzer, 2003). Researchers informed participants that investigators found a match between the defendant's DNA and some DNA that could be recovered at the crime scene. In addition, they provided participants with the necessary statistical information to quantify the uncertainty associated with the inference from data (positive match) to hypothesis (the defendant was the perpetrator). When researchers disclosed this information in probabilities, only 13% of the legal professionals and less than 1% of the law students correctly inferred the probability that the defendant was the source of the recovered DNA profile.

Many people, including experts, often believe that diagnostic tests are more accurate and more predictive than they actually are (Kurzenhäuser & Hoffrage, in press). Diagnostic test results remain central to decision making in a number of domains, and they can influence medical decisions, court rulings, and policy decisions. Thus, the experts who interpret and provide this information should realize the fallibility of these tests. Tests make correct as well as incorrect identifications. With medical screenings, a positive test result does not necessarily indicate that a person has the corresponding disease. Typically, the probability of infection or disease given a positive test result is still rather low. For example, based on their review of published studies, Gigerenzer et al. (1998) concluded that, among low-risk, heterosexual men who test positive in a HIV test, only about 50% actually are infected with the HIV. With mammography, the likelihood of breast cancer given a positive test is even much lower, about 8% (Gigerenzer, 2002).

Considering the HIV test example once again, most people, including health professionals, are astonished when they hear or read that the probability of infection is 50%. Most expect that a person with a positive test result has a 99.9% chance of being infected. Gigerenzer et al. (1998) conducted a study in which a low-risk client went to 20 German public health centers and obtained an HIV test at each of these centers. Before taking the tests, the client interviewed the counselors, focusing on numerical information in the context of HIV testing. Most counselors used percentages or probabilities to explain the risks. In the majority of the counseling sessions, the information that the counselors provided was either inconsistent or incorrect. For instance, one counselor estimated the base rate and the false-positive rate to be around 0.1%, and the sensitivity to be 99.9%. He then stated that the client's probability of infection, given a positive test, was also 99.9%. In fact, 15 out of the 20 counselors told this low-risk client that it is 99.9% or 100% certain that he has HIV if he tests positive. As we have detailed in the section regarding risk formats (see Figure 5.1), an effective method exists to make this information more transparent. The key is to present the information in a frequency format.

Even if risk communicators understand the quantitative risk information that they need to communicate, several reasons impact why they may not discuss risk or give statistical information to the public. American physicians most frequently mentioned lack of time as the reason for not discussing risks and benefits of cancer screening tests with their patients (Dunn, Shridharani, Lou, Bernstein, & Horowitz, 2001). In addition, many risk communicators are not trained in the communication skills required for discussing risks and benefits with their patients (Gigerenzer, 2002; Towle, Godolphin, Grams, & Lamarre, 2006). As Dunn et al. (2001) concluded, between a quarter and a third of the American physicians, who participated in the study, acknowledged that the complexity of the topic and a language barrier between themselves and their patients would keep them from discussing the benefits and risks of mammography screening.

HOW CAN OBSTACLES RELATED TO THE MESSAGE COMMUNICATOR BE AVOIDED?

Some of these obstacles can be avoided with proper training about interpreting numerical values, the appropriate use of statistical information, and effective communication skills. Communicators can be explicitly trained to translate conditional probabilities into a more understandable format for themselves and for their message receivers. For example, when researchers provided statistics regarding DNA profiles in terms of natural frequencies, 68% of legal professionals and 44% of law students made the correct inference (Hoffrage et al., 2000; Lindsey et al., 2003). Sedlmeier and Gigerenzer (2001) demonstrated that training people to encode information in terms of natural frequencies improves the accuracy of their probability judgments, compared to a control group in which students received traditional training (i.e., they learned how to apply mathematical formulas such as Bayes' theorem). When Kurzenhäuser and Hoffrage (2002) implemented representation training in a traditional classroom setting, they replicated Sedlmeier and Gigerenzer's finding that such training is much more effective in improving diagnostic inferences than training people how to insert probabilities into mathematical formulas. In both studies, researchers evaluated the success of the representation training by testing students with problems in which statistical information was given in terms of probabilities—the format that health professionals frequently encounter in medical textbooks (Kurzenhäuser & Hoffrage, in press).

In addition to proper skills training, risk communicators should adapt their quantitative messages to their audience and monitor if message receivers understand the statistical information. Freimuth, Linnan, and Potter (2000) suggested that effective communication must identify receiver characteristics, deliver accurate, scientifically based messages from credible sources, and reach audiences through familiar channels. If the message arouses fear, the communicator should provide ways to alleviate the fear. We now turn our focus to such characteristics of the message receiver that may hinder effective communication.

The Message Receiver

Risk communicators cannot assume that everyone possesses the same ability to understand risk information. Research indicates that a receiver's literacy and numeracy skills affect risk comprehension (Freimuth, Chervin, Hovick, Johnson-Turbes, 2007; Lipkus, Samsa, & Rimer, 2001; Schwartz et al., 1997). Likewise, studies show that the perception and processing of quantitative risk information may also depend on demographic factors and the emotional state of a receiver (e.g., Reyna & Brainerd, 2007; Peters, Lipkus, & Diefenbach, 2006).

LITERACY

To understand quantitative risk information, people first must understand basic issues, like the term "risk" and the concept of a reference class. In an earlier example, a doctor tells a man that his test result is positive. An individual with low health literacy may hear "positive result" and form the conclusion that he is not infected because, in most other contexts, the word *positive* signals good news. Although an extreme example, studies confirm that some receivers of risk messages experience difficulty with understanding basic terminology (Lipkus et al., 2001). In addition to familiarity with basic general terms, receivers must also grasp more specific concepts to which a statistic refers (e.g., mean, median, mode). The literacy and numeracy levels of the message receiver should be considered when sharing quantitative risk information.

Public health scholars have long been aware of the relationship between literacy and health education (Horner, Surratt, & Juliusson, 2000; Tappe & Galer-Unti, 2001). The U.S. Department of Health and Human Services (2000) defined health literacy as the degree to which individuals possess the capacity to obtain, process, understand, and act upon the spoken, written, and visual health information and services needed to make appropriate health decisions (also see Zarcadoolas, Pleasant, & Greer, 2006). Health literacy consists of a broad range of skills that allow people to make health decisions, including functional literacy (reading ability, writing ability, and speaking skills) as well as numeracy skills (the ability to manipulate numbers). A person's health literacy may be better or worse than his or her functional literacy, and functional literacy can be context specific. For example, people across high and low literacy levels may struggle to understand cancer screening recommendations (Davis, Williams, Marin, Parker, & Glass, 2002). On the other hand, a patient with low functional literacy, who is chronically ill and has been managing a disease for many years, may have more health knowledge that is specific to her illness than a person with high functional literacy who was diagnosed only recently or is not ill. Thus, one can expect that health knowledge varies considerably—both within a person across different domains and within a domain across different people.

In addition to the knowledge level of the receiver, a common problem in risk communication entails the use of complex technical terminology and jargon (Davis et al., 2001). Due to the use of complex terminology, the format of the information, and the literacy skills of the patient, researchers estimate that patients immediately forget 40% to 80% of the information that they obtain from medical practitioners (Anderson, Dodman, Kopelman, & Fleming, 1979; Kessels, 2003; Ley, 1979; McGuire, 1996). When unfamiliar information is combined with numerical data, this information is even more difficult to understand.

NUMERACY

Numeracy refers to the ability to understand and manipulate numbers (Peters, Hibbard, Slovic, & Dieckmann, 2007; Schapira et al., 2008; Zarcadoolas et al., 2006). According to Rothman, Montori, Cherrington, and Pignone (2008), it "is a multidimensional skill that involves assessing when to use numerical skills, deciding which skills to use, using the skills effectively to solve the problem, and then interpreting the results appropriately" (p. 592).

Numeracy skills become particularly important when decisions have to be made concerning medical treatment or lifestyle changes to lower a risk. Such decisions often benefit from taking evidence presented with numbers into account. However, as with health literacy, individuals possess different levels of proficiency in numeracy depending on their background and experiences (e.g., Adelsward & Sachs, 1996; Fagerlin et al., 2007; Grimes & Snively, 1999; Lipkus et al., 2001; Peters, Västfjäll, et al., 2006). In the United States, researchers estimate that half of the general population struggles to perform simple numeric tasks, like using a calculator or finding the difference between the regular price and the sale price while shopping (White & Dillow, 2005). Reyna and Brainerd (2007) established that low numeracy skills predict poorer health outcomes, less accurate perceptions of health risks, and compromised ability to make medical decisions. Reyna and Brainerd concluded that numeracy is essential to making health and social decisions in everyday life.

Individuals who are unable to perform simple tasks with numbers may experience even more difficulties when it comes to complicated manipulations and risk assessments. Lobb, Butow, Kenny, and Tattersall (1999) investigated the ability of women to understand breast cancer risk information. In this research, 53% of the women could not calculate how therapy would reduce their risk, and 73% did not understand the statistical term *median* when researchers used it to describe how long it takes for cancer to return. Black, Nease, and Tosteson (1995) concluded that numerate women were less likely to overestimate their chances of dying from breast cancer as well as the absolute risk reduction obtained by mammography.

Like individuals with low literacy, individuals with low numeracy skills are not always uneducated. Paulos (1988) was one of the first to shed light on the fact that even well educated people understand very little about mathematics and that intuitions about numbers often do not conform to simple mathematical rules. For instance, many people fall prey to the so-called ratio bias, according to which the ratio nx/ny appears to be larger than the ratio x/y. Yamagishi (1997) illustrated this point. For 11 well-known risks, college student participants were given estimations of the number of deaths in the population (i.e., 2,414 out of 10,000 or 24.14 out of 100) and asked to assess the riskiness of each. Yamagishi predicted that, for two mathematically identical ratios, the one with the larger numbers (in the numerator and the denominator) would lead people to assess a cause as riskier. Results supported this prediction; participants rated cancer as riskier when they were told that it "kills 2,414 out of 10,000 people" and rated cancer as less risky when they were told "cancer kills 24.14 out of 100 people." The same results were found across all 11 causes of death. As an explanation for the ratio-bias, Slovic, Finucane, Peters, and MacGregor (2004) posited that people usually find it easier to visualize the numerator of a ratio than its denominator.

Lipkus et al. (2001) measured the performance of educated participants on a numeracy scale. Most of the participants had more than a high school education, yet 16% were unable to correctly determine risk magnitude (i.e., what represents a larger risk: 1%, 5%, or 10%). Sheridan and Pignone (2002) investigated the numeracy skills of medical students. In their study, almost 25% of first year medical students could not manage basic numerical calculations. The students who had difficulty with the numeracy questions also experienced challenges with interpreting the treatment benefit of a hypothetical disease.

While it is a problem that educated individuals may have low literacy and numeracy skills when it comes to risk comprehension, individuals with low socioeconomic status and minorities, who are often at the greatest risk, more likely have low literacy and numeracy skills, which may add to their health risk (Fagerlin et al., 2007; Zarcadoolas et al., 2006). Although communicating health risks to these groups is especially important, only a few studies have examined how different cultural groups respond to risk information or the most effective approaches in communicating risk to diverse populations (Keller & Stevens 1997; Paling, 2003; Vaughn, 1995). This research has found that cultures view illness and health outcomes differently. For example, Hispanic women were more likely than non-Hispanic women to believe that illness constitutes a matter of chance and recovery can be attributed to good luck (Tortolero-Luna, Glober, Villarreal, Palos, & Linares, 1995).

AFFECT AND EMOTION

Risks are inherently threatening, and, at times, we cannot avoid arousing the emotions of a message receiver (Dillard & Nabi, 2006; Rudd, Comings, & Hyde, 2003). For instance, at the doctor's office or during a crisis like a natural disaster, people feel stressed, and this reaction influences the way that they process messages. Affective responses (e.g., mild positive or negative mood states), as well as emotional reactions (e.g., fear, sadness, anger, and anxiety), hold the potential to influence the processing of quantitative risk information. When risk decisions need to be made, people should be in a psychological and emotional position to comprehend the information that they receive, including the potential benefits and risks. However, when asked to make decisions or form judgments, people often rely on their internal affective responses and cues from the situation and may overlook important information (Peters, Lipkus, & Diefenbach, 2006; Slovic, Finucane, Peters, & MacGregor, 2002). When receivers experience affect at the moment that they attempt to process risk information, their emotions can influence cognitions, information processing, judgments, and decisions (Peters, Lipkus, et al., 2006; Slovic et al., 2004). For example, research indicates that people who rely on affect may pay less attention or give less weight to the numerical information in a message (Rottenstreich & Hsee, 2001; Watson et al., 1999). In addition, mood congruency can occur. Under negative mood states, perceptions and judgments skew toward greater negativity. As a consequence, if perception and judgments are negatively impacted, a person may make a different decision than he or she would in a positive mood state.

Raghunathan and Pham (1999) investigated the differential effects of sadness and anxiety on risk decision making. When asked to evaluate and make choices between two wagers, participants induced into a sad emotional state preferred the high risk and high reward option. The participants induced into an anxious emotional state preferred the low risk, low reward option. Doctors often ask patients to make medical treatment decisions very soon after receiving a diagnosis. Emotion can lead the patient to make a different decision than he or she would make under normal circumstances.

Considering that emotion and mood can affect decision making, we should recognize that some risk information, like a medical diagnosis or a bioterrorism threat, can cause emotional distress and may affect the processing of risk information. Considerable research reveals how stress affects message processing (e.g., Baron, Inman, Kao, & Logan, 1992; Lazarus & Folkman, 1984). During a crisis, people must deal with processing information as well as hearing, understanding, and remembering what they have been told. Anxiety caused by a stressful situation can prompt people to assume the worst (Covello, 1998), greatly influencing the interpretation of a diagnosis or risk information (for related review, see Galvin & Grill, this volume).

How Can Obstacles Related to the Message Receiver Be Avoided?

Rowan (1999) identified a number of frequent sources of confusion when explaining science to the public. First, familiar concepts to experts (e.g. exposure, toxic, and emission) are not well understood by the public. In addition to making sure that the receiver has a basic understanding of the concept of risk, communicators should avoid unnecessary jargon that the message receiver may not understand. Rowan suggested that we cannot simply define unfamiliar terms. She asserted that communicators should explain what a word, like *exposure*, means and also explicitly describe what it does *not* mean. In addition, a range of examples is more useful than providing just one instance. For example, a message could explain, "You can be exposed to a poison by eating it, touching it, or breathing it in." Finally, some risks are difficult to imagine—for example, we cannot see or smell carbon monoxide, but it is poisonous. This distinction needs to be made clear to the public.

In addition to clarifying any confusion, to be most effective, risk messages need to be culturally meaningful and provided in the native language of the receiver (Huerta & Macario, 1999; Keller & Stevens, 1997). Moreover, we should recognize that people with low socioeconomic status face barriers that influence their ability to address health risks including limited financial resources, a lack of knowledge about ways to address health problems, and inadequate health care or insurance coverage. A health message should consider these barriers and include ways to address these issues (Freimuth et al., 2007).

If health information is involved, risk communicators must explore and consider the general and domain specific health literacy of the message receiver. If necessary, message senders can utilize assessment tools, including the Rapid Estimate of Adult Literacy in Medicine (REALM; Davis et al., 1993) and the Test of Functional Health Literacy in Adults (TOFHLA; Parker, Baker, Williams, & Nurss, 1995) to evaluate the health literacy skills of potential receivers. Accordingly, health messages should be adapted to the knowledge level and skills of likely receivers.

When message senders communicate risk information to the public, they must make important considerations. Rudd et al. (2003) analyzed the content of two recent U.S. federal government mailings (the 1998 *Understanding AIDS* brochure, and the 2001 postcard in the aftermath of September 11) regarding the safety of the U.S. mail during the anthrax attacks. Researchers used the SMOG readability assessment tool to determine the reading level of both documents (McLaughlin, 1969). Government officials crafted the AIDS brochure at an eighth grade reading level, and the anthrax postcard was written at a 10th grade reading level, which means that both documents were written above the average reading level for half of American adults. Further, these materials were inappropriate for the 11 million American adults who are not literate in English (Kutner, Greenberg, Lin, Paulsen, & White, 2006). Simple changes could make materials like these easier to read and understand. For example, Rudd et al. pointed out that "notify local law enforcement authorities" can be more simply stated as "call the police." Notably, the text that is used in conjunction with the quantitative risk information matters just as much as the numbers themselves. Unnecessary jargon, which includes acronyms and multiple terms for the same condition, should be avoided.

Finally, risk communicators should consider the range of possible emotional reactions to their message. Peters et al. (2006) suggested that messages should explicitly mention common emotions. For example, if a mammography result is being given, the doctor could say that "it is normal to be worried about an abnormal mammogram. However, you should know that in order to avoid missing any cancers, we react if there is even the slightest reason to be suspicious. As a necessary consequence, there will be many women for whom we want to take a second look, and for whom we will later find out that there was nothing. In fact, most women your age, without a family history, who have an abnormal mammogram, do not have cancer."

The Communication and Perception of Risk

It is beyond the scope of this chapter to review the literature on risk perception due to the vast amount of research on that topic. Rather, we present a few core findings that are useful for considering risk perception in the context of communicating quantitative risk information.

Expert versus Public Perceptions of Risk

In a classic study on risk perception that included summaries of eight earlier research projects, Slovic (1987) argued that perceived risk is quantifiable, predictable, and that the concept of risk means different things to different groups of people. Slovic asserted that experts typically judge risk based on their estimates of annual fatalities. In fact, for experts, the term *risk* was synonymous with expected annual mortality.

Conversely, laypeople evaluate risks based upon other characteristics of the hazard, like catastrophic potential and the threat to future generations. According to Sandman (1993), laypeople concentrate on two components of risk. Sandman labeled the first component as the hazard, the technical side of the risk, the magnitude and probability of an undesirable outcome. In addition, people focus on the nontechnical side of the risk, including the negative aspects of the situation itself. Variables including voluntariness, controllability, fairness, memorability, and familiarity of the risk determine public outrage, explaining why many laypeople think that flying in an airplane is more dangerous than driving a car. Airplane crashes are more memorable, less familiar, and regarded as being less fair than car accidents. In addition, laypeople consider an airplane crash to be uncontrollable and dreaded.

Some evidence indicates that the public tends to believe that the knowledge of scientific experts is limited. For instance, Sjöberg (2001) reported that experts on nuclear waste believed that there is little unknown information in their field; however, politicians and the public held that many unknown effects exist. The unknown effects factor served as a better predictor of risk perception than trust for politicians and the public. This finding is consistent with Slovic (1987) who, by means of a factor-analytic model, identified the perceived level of knowledge about a particular risk as one of the two main dimensions of risk perception (the other factor was dread). These results suggest that an expert may have difficulty communicating a reassuring message because of the public's view that the expert may not have all of the relevant information. Science can only offer a reasonable assessment and can never provide proof.

Expert judgments are not always more accurate than lay judgments (Fiorino, 1989, 1990). The public can sometimes see problems and solutions that the experts may miss. From a communication perspective, we must acknowledge that experts and laypeople may construe risk in different ways (Slovic, 1987). Whenever possible, the public should be part of the message development process. Communication is enhanced when members of the intended audience participate in crafting the communication (Institute of Medicine, 2002). When target audience members assist with developing materials, the reading level of messages matches the ability of proposed readers more appropriately (Roter, Rudd, Keoge, & Robinson, 1986–1987; Rudd & Comings, 1994). Rudd et al. (2003) suggested that key reviewers should consult with members of the lay public, including people with less than a high school education before they distribute messages. In general, systematic differences between experts and a target group could affect risk communication.

Cultural Differences

While some differences in lay versus expert risk perception seem to be similar and stable across cultures, research offers evidence for cultural differences in perceptions of personal risks. Two of Hofstede's (1980) dimensions of culture can be used to understand cultural differences in risk perception. According to Hofstede, some cultures have a higher tolerance for uncertainty and ambiguity. Members of uncertainty avoiding cultures try to minimize the possibility of uncertain situations by embracing strict laws, rules, safety, and security measures. On a philosophical and religious level, these cultures believe in absolute Truth. On the opposite end of the spectrum are uncertainty-accepting cultures. These cultures express more tolerance for competing opinions and try to have as few rules as possible. In addition, these cultures accept competing religious and philosophical viewpoints simultaneously. Hofstede reported that uncertainty avoidance scores were higher in Latin countries, Japan, and German speaking countries and lower in Anglo, Nordic, and Chinese speaking countries.

Power distance also accounts for cultural differences in risk perception (Hofstede, 1980). This concept reflects the extent to which less powerful members of society accept and expect that power is distributed unequally. According to Hofstede's research, power distance scores were higher for Latin, Asian, and African countries and smaller for Germanic countries. Xie, Wang, and Xu (2003) suggested that citizens in eastern countries, like China, with a higher power distance and a hierarchical Confucian cultural heritage, worry more about war and social deviance that threaten the established forms of social relations, and worry less about technology risks. Research confirmed this prediction. Xie et al. conducted two surveys in China, one in Beijing and the other in the northeastern province of Shandong, in which they asked participants about the perceived risks of various threats. Results indicate that the Chinese participants were concerned most about risks that threaten national stability and economic development and less concerned with high-technology risk, such as threat from a nuclear power plant.

Bontempo, Bottom, and Weber (1997) investigated cross-cultural differences in the perception of financial risk. Participants from the U.S., the Netherlands, Hong Kong, and Taiwan rated the risk of several lottery gambles, decided if they would be willing to play, and indicated how much risk they would be taking if they did play. Participants from the United States and the Netherlands were less sensitive to the magnitude of potential losses than participants from Taiwan and Hong Kong. Also, positive outcomes had a smaller reducing effect on perceived risk for the Taiwan and Hong Kong participants than participants from the two western cultures.

Differences in risk perception also emerged with regard to gender and age. Females across cultures and age groups tend to perceive risks as being higher than males perceive them to be (Flynn, Slovic, & Mertz, 1994; Jelalian et al., 1997; Slovic, 1999; Xie et al., 2003). In addition, younger people tend to perceive less personal risk than older people. Compared to adults, teenagers minimize the perceived risk of health-threatening activities (Cohn, Macfarlane, Yanez, & Imai, 1995). Gender and age differences in the perceptions of risks can already be observed during childhood. In their study comparing6, 8, and 10-year-old children, Hillier and Morrongiello (1998) found that boys rated risk as lower than girls and that 6-year-olds identified fewer risk factors (and identified risk factors more slowly) than 10-year-olds.

Qualitative Risk Information

Most research comparing qualitative and quantitative information does not suggest that one form of evidence is superior to others (Cacioppo, Petty, & Morris, 1983; Reinard, 1988). This chapter provides an overview of common obstacles in the communication of quantitative risk and describes how quantitative information should be presented. Yet, quantitative information may not always be available, and, at times, it is more appropriate to give qualitative risk information. Qualitative evidence includes narratives, personal anecdotes, case histories, personal stories, and testimonies (Baesler & Burgoon, 1994; Beck, 2001; Harter, Japp, & Beck, 2005; Kahneman & Tversky, 1982; Kazoleas, 1993; Kopfman et al., 1998).

Like numbers, narratives can serve as evidence for a particular conclusion. Beck (2001) suggested that personal stories provide a way of understanding risk that cannot be provided by giving "just the facts." By being able to merge fact, values, reason, and emotional content, such stories may be used in combination with quantitative information to inform or persuade. Kreuter et al. (2007) argued that narrative constitutes an appealing form of evidence due to its familiarity. People communicate and learn about the world through stories (Fisher, 1987).

According to Kreuter et al. (2007), narrative communication (including entertainment education, journalism, literature, testimonials, and storytelling) offers four distinctive capabilities. First, narrative communication can address the bases for resistance to change. A narrative can model a behavior by telling a story about a person who performed it successfully. Next, narratives facilitate information processing. The authors suggest that humans are hardwired to process stories and narrative communication. Third, narratives provide surrogate social connections. People can develop relationships with characters in stories. Thus narratives serve a social support function. Finally, narratives can address emotional and existential issues where other forms of evidence cannot.

Discussion

Research on the communication of quantitative risk information is relevant to scholars across the communication discipline. Communicators exchange risk information in both interpersonal and mass communication settings. Further, risk communication occurs in a variety of domains, including health, environmental, public policy, and technology. Risk communication takes place at the organizational level where policies are being made, but also in the family. An organization must assess the risk of an intentional attack in the United States, but a family then must understand this risk and decide if they need to create a disaster preparedness kit and make an evacuation plan. Finally, on the individual level, communication scholars must look at the differences in message receivers. We could benefit from more research regarding cultural differences, including religion, and the processing of quantitative risk information. An important topic for future research involves the communication of risks to people with a low functional literacy. Likewise, we should conduct more research to better understand how different racial and cultural groups process risk messages and how risks can be communicated most effectively to diverse populations (Keller & Stevens, 1997; Paling, 2003; Vaughn, 1995).

Qualitative and quantitative evidence have been studied extensively in the field of communication (Reinard, 1988; R. A. Reynolds & J. L Reynolds, 2002). Most of the research has focused on determining what types of messages are most vivid, memorable, or persuasive. A meta-analysis of 15 studies, conducted by Allen and Preiss (1997), indicates that statistical evidence is generally slightly more persuasive than qualitative messages that use examples or narratives. However, although people may learn quantitative information and be persuaded, they may be unable to apply it accurately in the future. Both qualitative and quantitative evidence can be effective in changing attitudes (Kazoleas, 1993).

Despite this large body of work, many questions remain unanswered. Research should continue to systematically explore the different dimensions of quantitative and qualitative evidence. Hample (2006) suggested that a theory of evidence would help to organize the research in this area. He asserted that a theory could be generated by descriptive study of evidence in use. Future research endeavors should investigate how people distinguish pieces of evidence and systematic investigations of the effects of evidence should be conducted.

Finally, more research that considers the role of emotion in risk communication is needed. Separate actions are involved in experiencing an emotion or a mood state, and in then relying on those feelings to make a risk related decision. People differ in terms of their emotions and affect when processing risk information, and further research can elucidate when such differences may occur.

Conclusion

Unfortunately, we recognize some truth to Mark Twain's (1907 statement, "there are three kinds of lies: lies, damn lies, and statistics." Numbers can be deceiving, misleading, and misinterpreted. What is most objectionable is when experts will sometimes make intentional use of false numbers. Although we hope that this deception does not happen very often, a false number that is understood correctly, and a correct number that is misunderstood, may ultimately have the same effect. While no universal or magic way of communicating quantitative risk exists, this chapter reviewed a number of steps that can be taken to make risk information more understandable.

Effective risk communication begins with the message sender. Health practitioners have an obligation to inform the public in an appropriate way, particularly in situations when a patient is not ill, such as preventative health campaigns (Kurzenhäuser & Hoffrage, in press). In preventive screening, the number of participants who benefit from the test (those who have an early stage of the disease and would profit from early treatment) is rather small; whereas, the side effects of the test (e.g., exposure to x-rays during mammography) affect all participants.

The characteristics of the message receiver also should be taken into consideration. Doak, Doak, Friedell, and Meade (1998) offered several strategies to improve the comprehension of patients with low literacy skills. First, for verbal communication, Doak et al. asserted that the communicators provide an agenda for the conversation and limit new information to key points that are needed immediately. Second, the communicator should focus on behaviors and actions, and partition long lists of recommendations into smaller parts. Third, the communicator should present the context first, then the new information. Examples (such as pictures, sketches, models, or visuals) should be used, if appropriate. Finally, the message sender must obtain feedback from the message receiver to verify comprehension of quantitative risk information. Most importantly, a risk message has to be clear and understandable. Representations of quantitative information constitute communication tools. A communicator should select the best tools available to communicate his or her message. The selected statistical representation affects how receivers will understand the numbers. Thus, this choice can influence a number of receiver decisions. For example, a patient may choose a treatment option, select a medication, or make lifestyle changes based on the risk information presented. Research indicates that some numbers, like natural frequencies, are easier to understand than others. Several studies have shown that frequencies improve Bayesian reasoning compared to probabilities and percentages (Brase, 2002; Hoffrage et al., 2000; Kurzenhäuser & Lücking, 2004; Lindsey et al., 2003; Mellers & McGraw, 1999). Statements with absolute frequencies also have another major advantage—they resolve the ambiguity of which reference class is chosen. The reference class, to which a single-event probability pertains, should always be given.

Communication scholars and practitioners who confront the difficult task of communicating quantitative risk information to the public and to consumers of their messages especially benefit from research regarding representation formats. Our review provides a spotlight rather than an exhaustive overview of the rich literature on risk communication. We focused on quantitative risk communication, which has notoriously been interpreted as being complex and difficult to understand. Research on risk formats comprises one area in which communication theories can help us improve the effectiveness of our messages. However, we need more research to better understand and overcome the hurdles inherent in risk communication. We believe the reviewed literature provides some promising avenues for future research, and we hope it inspires communicators who face the challenging task of communicating quantitative information.

NOTES

1. The prevalence rates of HIV and, therefore, also the positive predictive value of the HIV test refer to heterosexual men in Germany who are 20 to 30 years old and do not engage in risky behavior. This rate "is in the range of the prevalence of HIV in blood donors in the U.S. (a group with low prevalence within the U.S.), which has been estimated at one in 10,000 (Busch, 1994, p. 229) or two in 10,000 (George & Schochetman, 1994, p. 90)" (Gigerenzer et al., 1998, p. 199). A recent study on prevalence of HIV among young adults (18–28 years) in the United States (Morris et al., 2006) found similar prevalence rates for women (8.7 in 10,000) and for men (10.6 in 10,000). Note that these rates are about 10 times higher than the rates in the 1994 American samples. Moreover, in the Morris et al. study, the prevalence rate for non-Hispanic Blacks (49 in 10,000) differed remarkably from the prevalence rate found for members of other ethnic groups (22 in 10,000). The sample refers to 14,322 individuals out of 18,924 targeted individuals of a representative sample who agreed to participate (a participation rate of 75.7%).
2. Similar to HIV tests, the results of mammography screenings are not always correct. In fact, HIV tests are more accurate than mammography screenings (see Table 5.1). As a consequence, analyses similar to those displayed in Figure 5.1 revealed that the chance that a low-risk woman between the age of 40 and 50 suffers from breast cancer given that she has a positive result in a mammography is about 8% (Gigerenzer, 2002). In empirical studies, women typically overestimate this probability (Kurzenhäuser & Hoffrage, in press).

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