

What Does It Mean to Understand a Risk? Evaluating Risk Comprehension

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Risk communications are frequently intended to help people understand hazards they face, with the hope that this understanding will help them make better decisions about the need for action or help them choose among alternative actions. To evaluate the success of such communications, a definition of “understanding” is needed. This paper suggests that decisions about personal risks require, at a minimum, information about the nature and likelihood of potential ill effects, information about the risk factors that modify one’s susceptibility, and information about the ease or difficulty of avoiding harm. Even if these attributes are accepted as essential criteria for understanding, research on risk perceptions suggests that assessing what people know or believe is sometimes quite difficult. The focus of the paper is on the several dimensions of risk comprehension. Examples of how each can be assessed are drawn from research on public perceptions of the risks from smoking. These examples demonstrate that the public has only a limited understanding of smoking risks. [Monogr Natl Cancer Inst 1999;25:15–20]

GOALS FOR RISK COMMUNICATION

Many reasons exist why risk information may be communicated to the public or to individual patients: build trust, influence policy, fulfill legal obligations, deny responsibility, justify past actions, and more. Among the most important is the goal of helping people understand the risks they face. The expectation is that this understanding will help people better decide which hazards they should accept and which they should avoid or reduce.

But what does it mean to “understand a risk”? To determine how much the public understands about a hazard or to evaluate how effective a risk communication has been, an appropriate measure of understanding is needed. Hazards are complex and multidimensional, so a useful and defensible definition is far from obvious. Attempts have been made to establish criteria for assessing the success of a single-risk message (1), to specify what policymakers need to know about a risk (2), and to provide a comprehensive examination of the entire risk communication endeavor (2,3), but no one has tried to specify the minimum information needed by an individual to understand his or her own risk. This paper will draw on the decision-making and

health behavior literature to identify a small set of risk attributes that are essential knowledge for informed personal decision making, and it will draw on the risk perception literature to offer suggestions about how lay knowledge of these attributes might be assessed.

Despite this paper’s focus on understanding, decisions and behavior are not determined by knowledge alone. Many other factors are involved and are sometimes much more powerful. These factors include emotions, personal values, social pressures, environmental barriers, and economic constraints. Educated individuals do not always make wise decisions. Still, without an understanding of the risk, appropriate decisions about personal action can come only from luck or from following someone else’s advice or example, neither of which is a dependable guide.

DIMENSIONS OF RISK COMPREHENSION

A comprehensive understanding of the risks from smoking would include such diverse topics as the identity of the chemicals in cigarette smoke, the transport and metabolism of these chemicals in the body, the economic costs of smoking, and the types of therapies used for smoking-related illnesses. If all of these topics are required for “understanding,” few if any lay people can ever be expected to understand the risks of smoking. However, such complete knowledge is not needed to decide whether one should smoke. To make decisions about the importance of avoiding a particular hazard, such as smoking, people need, at a minimum, information about the nature and likelihood of potential ill effects, about the risk factors that modify their susceptibility, and about the ease or difficulty of avoiding harm.

A focus on these particular risk dimensions is consistent with a large body of theory and research on health behaviors (4) and decision making under uncertainty (5–7). All of these theories explicitly consider the severity of the potential harm. That is, the theories assert that people are influenced by how serious they think it would be if the hazardous outcome occurred. A prereq-

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quisite for any accurate judgment of severity is obviously an understanding of the identity of the harm that might occur.

A second variable in relevant theories of decision making and behavior is the probability of the harm. In other words, what are the chances that it will occur if no preventive steps are taken? The probability of harm is rarely the same for everyone, so understanding one's personal vulnerability requires knowledge of the main factors—such as personal behaviors, family history, and environmental exposures—that determine that probability. “Controllability” is another concept found in theories of health behavior (8). It denotes the reduction in the likelihood of harm that can be achieved by preventive action, so it can be viewed as one facet of understanding the probability of harm.

A final crucial topic is the ease or difficulty of carrying out actions to reduce the risk. Experience shows that people frequently underestimate the difficulty of carrying out preventive activities, so this topic should also be considered essential to informed decision making.

Many other risk dimensions might influence decisions and therefore might be considered necessary to understanding: slowly appearing versus rapidly appearing, familiar versus unfamiliar, vivid versus pallid, affecting many people simultaneously versus affecting individuals one at a time, natural versus man-made, and so on (9). Because there is neither agreement nor much data about how influential these dimensions are, they do not seem to be essential to a core definition of risk understanding, although some might be very important in particular situations.

Clearly, no single question can ascertain whether people understand a risk. Only multiple queries will allow us to reach valid conclusions about the extent to which people understand a risk and the types of information they are lacking.

The remainder of this paper will elaborate on the risk dimensions just mentioned, including ways in which they might be assessed. Examples will be drawn from research on the public's views of smoking, including a recent review of the accuracy of smokers' risk perceptions (10). Although the examples from the smoking literature provided here do not form a complete review of the smoking data, they nevertheless indicate that public knowledge—when compared to a comprehensive definition of understanding—is inadequate. Most people still do not understand the risks of smoking, and what they do know does not form an adequate basis for decision making.

ESSENTIAL CRITERIA FOR JUDGING COMPREHENSION

The Nature of the Potential Harm

Judging the severity of a hazard requires more than a vague understanding that an activity is “bad for you” or that it “causes cancer.” Unless a person has a reasonably complete knowledge of the undesirable consequences of that activity—both what outcomes can occur and how serious these outcomes are—he or she is not in a position to decide how negative the consequences might be.

The Identity of the Health Outcomes That Can Occur

When surveys or interviews focus on a particular health problem, such as breast cancer, stroke, or acquired immunodeficiency syndrome (AIDS), the identity of the health threat is self-evident. However, research on risky behaviors and environmental hazards, such as smoking, alcohol abuse, or lead expo-

sure, should not assume that people know what illnesses or disabilities may result.

Example: What are the potential health consequences of smoking? Can people generate a reasonably complete list of the illnesses that are caused by smoking? Do they acknowledge that smoking can cause these illnesses?

A major problem with most attempts to learn whether people know what illnesses are caused by smoking is that the correct answers are implicit within the questions. Respondents are asked whether smoking can cause heart disease, lung cancer, and so forth. The questions thus remind people of the health effects that are of concern and suggest what answer is correct. Such prompted recall is a much more lenient measure of knowledge than unprompted recall. Without being prompted in this way, it appears that many people cannot identify even the best-known, most serious illnesses caused by smoking. In two older studies cited in the 1989 Surgeon General's Report (11), for example, only 32% of blacks surveyed and only 54% of a primarily white sample mentioned smoking when asked about the most important causes of cardiovascular disease.

It appears that for at least several decades, no survey in the United States has asked people, in an open-ended format, what illnesses can be caused by smoking. A 1990 Canadian survey (12) inquired, “To the best of your knowledge, what, if any, are the health hazards related to smoking?” The results were that only 44% of respondents cited lung cancer, only 20% cited heart disease, only 20% cited emphysema, and only one in 20, or less, cited other smoking-related illnesses such as high blood pressure, oral cancer, respiratory problems, bronchitis, or stroke. A weakness of this study is that prompts (e.g., “Can you think of anything else”?) were not used to encourage people to try to add to the list of illnesses that they had already mentioned.

If individuals cannot identify even the best known, most severe health effects of smoking without prompting, they are certainly unable to apply that information in deciding whether to smoke.

When questions ask about specific effects, lung cancer, heart disease, and emphysema are the diseases most commonly associated with smoking by the lay person. A large majority of survey respondents agree that cigarettes can cause those illnesses (13). However, significant minorities of smokers do not agree. For example, according to the most current data reported in the 1989 Surgeon General's Report (11), 29% of the smokers did not agree that smoking causes heart disease; 17%–25% did not agree that cigarette smoking causes lung cancer; and 21%–25% did not believe that smoking causes emphysema or chronic bronchitis. Similarly, in Australia, Chapman et al. (14) found that only about 50% of the smokers agreed that smoking can cause heart disease, poor circulation, bronchitis, and stroke, and only 72% agreed that smoking can cause lung cancer.

The Seriousness of These Outcomes

Perhaps because most health behavior research focuses on illnesses or risky behaviors that are serious and relatively familiar, it is assumed that lay people are well informed about the nature of these problems. Efforts are seldom made to determine what people know about the symptoms or duration of illness, the possible aversiveness of treatment, the success of therapies, and similar issues. Neither do researchers know which of these characteristics or others are the most important influences on health behaviors.

Example: How serious are the consequences of smoking? Are people aware of the difficulty or impossibility of curing these illnesses, of the severe ways in which smoking-induced chronic illnesses alter people's lives, and of the number of these illnesses that are potentially fatal?

Basic to understanding the severity of the consequences of smoking is appreciating what it is like to have lung cancer, heart disease, or emphysema and the chances of mortality from these diseases. Can people describe the debilitating symptoms of emphysema? Do people understand how deadly lung cancer is? Seldom are attempts made to answer such questions. The Canadian study cited earlier (12) found that people substantially underestimated the mortality rate from lung cancer, estimating on average that only 64.7% of cases of lung cancer result in death.

Some evidence shows that adolescents especially underestimate the severity of the harm from smoking. For example, adolescents gave lower ratings for the amount of harm caused by occasional, experimental, and regular smoking than did their parents (15).

The studies just cited may convey a false impression that an individual's appreciation of the severity of an illness can be determined adequately from numeric ratings. Abundant evidence (16) shows that people are affected more by concrete examples and vivid images than by pallid statistics. Thus, knowledge of illness statistics—survival rates, illness durations, and so forth—surely fails to capture important aspects of illness awareness. Researchers might find ways to compare the perceptions of respondents with those of people who have actually experienced a disease, using the latter perceptions as a standard of accuracy.

The Probability of Harm

Assessing lay perceptions of probability is extremely challenging because members of the public do not appear to think in terms of rates, percentages, or odds, the units used by scientists to express event likelihood.

The Probabilities as Expressed in Absolute, Numeric Terms

A natural inclination is to ask people for numeric judgments of likelihood and to compare their responses with epidemiologic data. This approach conveys an impression of rigor and scientific objectivity, but conclusions about understanding reached in this way are highly questionable. Viscusi (17,18), for example, implies that, when people are asked to give a numeric estimate of risk (e.g., the number of smokers out of 100 who will develop lung cancer or the likelihood of living to a certain age), the answers they give are meaningful to them and show whether people understand the risks of smoking. Such interpretations are simply not borne out by the data.

Lay people often have great difficulty understanding and using numeric estimates of risk. This fact is well known and well documented in the literature. For example, Lipkus et al. (personal communication, 1998) asked people, about 80% of whom had at least some college education, extremely simple questions regarding probabilities and percentages, with stunning results. Approximately 20% of the respondents (and about 40% of the smokers) were unable to correctly answer the following question: "If the chance of getting a disease is 10%, how many people on average would be expected to get the disease out of 100?" Yamagishi (19) found that people rated a cancer as riskier

when it was described as killing "1286 out of 10000 people" than when described as killing "24.14 out of 100 people."

Similarly, Black et al. (20) found that 38% of their generally well-educated sample (62% college graduates) made fundamental, logical errors in making numeric risk estimates. For example, some respondents gave a higher estimate for the likelihood of contracting breast cancer sometime in the next 10 years than for the likelihood of sometime in the next 20 years, whereas others gave a higher estimate for the likelihood of getting and dying of breast cancer than for the likelihood of getting breast cancer in the first place.

Data also indicate that people's actions sometimes bear little relation to statistics denoting absolute risk. A study by Shiloh and Saxe (21), for example, found no correlation between the probabilities provided to couples during genetic counseling and the decisions they then made about childbearing. Windschitl and Wells (22) reported that judgments of likelihood using verbal categories predicted subsequent actions better than did numeric likelihood estimates. Consistent with that result, Diefenbach and Weinstein (23) found that college students said that scales of risk with verbal labels (e.g., "very unlikely") were easier to use and did a better job of representing their true feelings than did numeric scales using either odds or percentages.

All together, the available evidence shows that a large proportion of the public has enormous difficulty with odds and percentages. The ability to cite a statistic or make a numeric estimate does not mean that people understand what the number really means, that they use it in making decisions, or that they think it applies to them. Asking survey respondents to place a numeric probability on the occurrence of a health outcome and then comparing their answers with objective data is one of the least meaningful and least reliable measures of risk understanding.

Example: Can people correctly state the number of smokers out of 100 who will contract heart disease, lung cancer, or other smoking-related illnesses by a certain age? Can people correctly state the fraction of smokers who will prematurely die because of smoking? Can people correctly state the proportion of a specific illness, such as lung cancer, that is caused by smoking?

Borland (24) conducted several studies that used numeric risk assessments. In one, respondents were asked about the numeric risk of dying from three smoking-related diseases. When the risks of just those three diseases were added up, the total chance of dying was already more than a 100% (approximately 120%). Borland concluded that people do not respond to such questions with answers that obey the laws of probability.

Several studies that collected numeric probability estimates found a surprising number of people who estimated the risk of lung cancer from smoking as "50%" or as "50 out of 100"—as many as 37% of the respondents (Sutton SR: personal communication, 1995). Such a spike in the distribution of responses strongly suggests that people were using 50% as a sort of default answer, because they did not have any better notion of how to answer the question. It is likely that many of these respondents did not mean that the risk was actually one in two, but rather that the outcome might or might not happen.

The impossibility of using numeric risk estimates to decide whether people understand the risks of smoking is further demonstrated by the fact that studies forcing survey respondents to place numeric values on smoking outcomes yield inconsistent

answers about the accuracy of the public's perceptions [see Table 1 in (10)]. In some studies (17,18), people appear to exaggerate the risks, estimating, for example, that about 40 smokers out of 100 eventually develop lung cancer, whereas a more accurate figure would be closer to 5% or 10%. Other studies suggest that people underestimate the risks. In a representative national sample in England (25), the median response was that 100 out of 1000 smokers would die because of smoking before age 70 years. According to Sutton (25), the epidemiologic data indicate that the actual number of deaths as a result of all smoking-induced illnesses is 250.

Even though lay answers to such questions are problematic, it might appear that the questions, at least, are clear and objective. This clarity, however, is illusory. The questions do not define "smoker" and leave ambiguous the number of cigarettes a day that are smoked or the number of years of smoking. When asked about a "smoker," most respondents will bring to mind a person who smokes rather heavily. The risks they estimate for an undefined smoker are probably higher than if they had been asked to consider the real world population of all smokers, which includes light smokers. Another flaw with such questions is the failure to ask people about their own risk, because we know that people seldom believe that the risks faced by others apply to themselves (see below).

The Relative Probability of the Hazard

If numeric measures of probability (e.g., the probability that a man 50 years of age will eventually develop prostate cancer) have little meaning for most people, how do they think about the likelihood of harm and how can we assess the accuracy of their thoughts? Do people use some set of verbal categories to think about likelihood? Do they think in terms of the absolute magnitude of individual risks, or do they relate more naturally to relative risks (i.e., which risks are bigger or smaller than others)? Do people even pay attention to absolute risks, or do they care more whether their own risks are higher or lower than the risks of their peers? As these questions suggest, there are many possibilities and even more assessment strategies. At present, there is no agreement concerning the answers to these questions.

An attractive alternative to judgments of absolute risk is to determine whether people have an accurate sense of the relative risk. Recognizing the public's difficulty with numeric estimates, relative risk should be assessed with rankings of different hazards or with qualitative comparisons (e.g., "the two hazards are 'about the same,'" or "hazard 1 is 'much greater' than hazard 2"), rather than with numeric estimates (e.g., "hazard 1 is 80% greater than hazard 2"). The following kinds of comparisons seem familiar and natural.

How does the probability of harm from the hazard of concern compare to the probability of harm from other familiar hazards? People deal with risks all the time, although not necessarily consciously. When making decisions about a hazard, it is helpful to consider how it compares with others for which one has already made decisions. This argument suggests that an adequate understanding of a risk includes an ability to place the risk into a real-life context in which a variety of hazards compete for attention.

Example: In relative terms, do smokers understand how the harm from smoking-induced illness compares with the harm from other familiar hazards, such as automobile fatalities, murder, and AIDS?

The evidence indicates that people do not understand how smoking compares with other risks. In an American Cancer Society study (26), 28% of American voters believed that auto accidents kill more people than any other hazard on a list they saw that included cigarette smoking, drug use, AIDS, alcohol abuse, and murder. Only 21% recognized that cigarette smoking was the biggest killer on the list, although more deaths are attributable to cigarette smoking than to all the other listed health problems combined. Similarly, the 1989 Surgeon General's Report (11) cites a survey in which teenagers were asked to pick out the hazard that caused the most fatalities from a list that included traffic accidents, drug overdoses, fires, and cigarette smoking. The largest group, 44%, identified traffic accidents as the greatest hazard, followed by drug overdoses. Only 19% chose cigarette smoking. Similar underestimations of the relative risk of smoking have been reported by Borland (24) and Eiser et al. (27).

How much is the probability of harm for someone at risk elevated above that of someone who is not in the same risk category? When the hazard in question is a particular risk factor, such as unsafe sex, a high-fat diet, or asbestos exposure, an obvious issue is the extent to which these risk factors raise the likelihood of victimization above that of people without these risk factors.

Example: In relative terms, do people realize how much the risk of smoking-related illnesses is increased above the risk of nonsmokers? Do they realize that smokers are substantially more likely to die prematurely? How do smokers' perceptions of the risks of smoking compare with nonsmokers' perceptions?

All the available studies indicate that the great majority of lay people realize that smoking is harmful and believe that the risk of diseases like emphysema and lung cancer is higher for smokers than nonsmokers [see Table 2 in (10)]. It is also found consistently, however, that smokers believe these health effects to be smaller and less well established than do nonsmokers [see Table 3 in (10)].

Quite a few studies have asked smokers how their risk of becoming ill from smoking compares with the risk of the average person (or the average person their age). In a representative national sample, Ayanian and Cleary (28) found that 71% of smokers believed their personal risk of heart attacks to be average or below average when compared with the risk of other people of their age and sex, and 60% believed that their personal risk of cancer was average or below. In other studies, the mean comparative risk judgments of smokers ranged from "average" (i.e., smokers claimed that their own risk was no different than that of the average person) to "a bit higher" (Sutton SR: personal communication, 1995). In no case did smokers acknowledge that their risk of lung cancer, heart disease, or emphysema was "moderately," "substantially," or "much" higher than that of the average person. Because the epidemiologic data show that smokers' risk of getting these diseases is greatly elevated relative to nonsmokers (11), for smokers to believe that their risk is hardly different from average demonstrates a clear failure of understanding.

Finally, Chapman et al. (14) found that smokers maintain a constellation of comforting, risk-minimizing beliefs. About one third of smokers, for example, agreed that "Many people who smoke all their lives live to a ripe old age, so smoking is not all that bad for you." For each of the 14 different risk-minimizing beliefs examined, smokers agreed more than did exsmokers.

What is the size of one's own risk compared with others with similar risk factors? Research has shown that risk perception is not an unbiased appraisal of information, but rather an attempt to seek the most comforting view of one's personal vulnerability that fits within the bounds of the evidence. As a result, whatever people believe about the risks faced by others, they tend to believe that their own personal risks are less (29,30)¹. This phenomenon is robust and appears in many different groups, with various methodologies, and with nearly all hazards. Thus, the result of asking people about the likelihood that they personally will have a problem can be quite different from the result of asking them about people in general or about people their age.

This optimistic bias appears to be equally descriptive of adults and adolescents (10,31). The magnitude of unrealistic optimism (i.e., the difference between risk estimates for oneself and for others) varies from hazard to hazard, but it is particularly large for problems, like lung cancer, that are believed to be preventable by individual action.

Example: In relative terms, how do smokers' views of their own risk compare with their views of the risk to other smokers? Do smokers realize that the risks of smoking apply to them, or do they believe that they are for some reason less at risk than other smokers?

Numerous studies [see Table 4 in (10)] demonstrate that smokers believe their risks from smoking are significantly lower than the risks for other smokers. Additional studies reveal a variety of mechanisms or rationalizations used by smokers to minimize their risk. For example, smokers' estimates of the number of years of smoking needed to produce adverse health effects increase with the number of years they have been smoking (32). Smokers also claim that their cigarettes' tar content is lower and that their cigarettes are less hazardous than the average brand (11,33).

The Factors That Influence Individual Susceptibility

Seldom is everyone's risk the same. People should be able to recognize when their risk is substantially higher or lower than the norm. Such moderating variables might include their behaviors, physiology, genetic inheritance, or environment. Not only is it important to determine whether people recognize the factors that alter their risk, but it is also equally important to discover the myths that they hold about risk factors. People tend to believe myths that help them feel that they are not at risk.

Example: How does the risk vary with the duration and amount of smoking? Does having a lifestyle that is otherwise healthy counteract the effects of smoking? Is it okay to smoke for a few years? Are there safe cigarettes?

Several studies provide data on this topic. Hahn et al. (32) found that among long-term smokers, those who smoked more cigarettes rated themselves as being at higher risk of developing smoker's cough than light smokers. However, among short-term smokers, there was no relationship between the amount they smoked and their perceived risk of illness. This finding is consistent with research by Slovic (34) showing that adolescents think that they can smoke for a while without risk. For example, 32% agreed that "there is really no risk at all for the first few years."

LoConte (35) explored agreement with a variety of misleading but comforting beliefs about risk-moderating factors. These factors included the ability to reduce one's risk with special

patterns of smoking (smoking outdoors, periodically abstaining, smoking only part of each cigarette) or to counteract the risk with health-promoting behaviors (exercise, relaxation, diet). Consistently, smokers agreed more strongly with these thoughts than did nonsmokers.

The Difficulty of Avoiding the Harmful Consequences of the Hazard

Some precautionary behaviors—obtaining a vaccination, using seat belts, taking vitamins—are relatively easy to perform. Many others—losing weight, practicing safer sex, stopping smoking—are notoriously difficult. Knowledge about barriers to change can influence the willingness to be exposed to hazards for which arduous remedial measures might later be needed.

Example: Do people realize the addictive power of cigarettes? Especially at the time when they initially begin to smoke, do they think that they will be able to quit if they so choose?

For smoking, a key aspect of understanding is a recognition of the likelihood of becoming addicted. Studies demonstrate that adolescents underestimate the likelihood that they will get addicted to cigarettes and overestimate the likelihood that they will stop smoking. For example, the 1989 Surgeon General's Report (11) described two surveys which found that about one quarter of teenagers agreed with the statement, "Teenagers who smoke regularly can quit for good any time they like."

Cohn et al. (15) asked teenagers about their chances of encountering 19 problems—one of which was to "get hooked on cigarettes." The illusory belief that they were less likely to become addicted than their peers was greater than the optimism shown for any other problem, with the single exception of "getting hooked on drugs like marijuana." Teens were also more confident than their parents that they could escape addiction to cigarettes.

In a University of Michigan survey, "Monitoring the Future," high school seniors were asked, "Do you think you will be smoking cigarettes 5 years from now?" [cited in (36)]. Of seniors who smoked less than a cigarette per day, approximately 85% stated that they probably or definitely would not still be smoking after 5 years. When the same group was polled 5 years later, 58% had not quit smoking. Almost one third of seniors who smoked a pack a day thought that they, too, would quit within 5 years. After 5 years, only 13% had actually quit.

CONCLUSION

To assess someone's understanding of a health hazard is to study the constellation of beliefs that are relevant to decisions and behaviors concerning that hazard. Just as no single question can ascertain a person's understanding of the judicial system or a person's understanding of the human body, scientists must use a variety of questions and approaches to learn what people understand about a risk. A basic set of essential points would include the identity and severity of the potential harm, the likelihood of harm under various circumstances, and the possibility and difficulty of reducing that harm. To make a decision, the same types of information would be needed about any other alternatives under consideration. Most current studies of hazard perception or knowledge fail to examine even this limited range of risk dimensions and use methodologies that are questionable. By identifying a small number of core issues and by pointing out some problems in their assessment, it is hoped that this paper will encourage researchers and communicators to pay close at-

tention to the kinds of information people need to make appropriate risk decisions.

REFERENCES

- (1) Sandman PM, Weinstein ND. Some criteria for evaluating risk messages. *Risk Anal* 1993;13:103–14.
- (2) National Research Council. Improving risk communication. Washington (DC): National Academy Press; 1989.
- (3) Stern PC, Fineberg HV, editors. Understanding risk: informing decisions in a democratic society. Washington (DC): National Academy Press; 1996.
- (4) Conner M, Norman P, editors. Predicting health behaviour: research and practice with social cognition models. Buckingham (UK): Open University Press; 1996.
- (5) Camerer C. Recent tests of generalizations of expected utility theory. In: Edwards W, editor. Utility theories: measurements and applications. Boston (MA): Kluwer Academic Publishers; 1992. p. 207–51.
- (6) Edwards W. The theory of decision making. *Psychol Bull* 1954;51:380–417.
- (7) Kahneman D, Tversky A. Prospect theory: an analysis of decision under risk. *Econometrica* 1979;47:263–91.
- (8) Ajzen I, Madden TJ. Prediction of goal-directed behavior: attitudes, intentions, and perceived behavioral control. *J Exp Soc Psychol* 1986;22:453–74.
- (9) Slovic P. Perception of risk. *Science* 1987;236:280–5.
- (10) Weinstein ND. Accuracy of smokers' risk perceptions. *Ann Behav Med* 1998;20:135–40.
- (11) U.S. Department of Health and Human Services (USDHHS), Public Health Service. Reducing the health consequences of smoking—25 years of progress. A report of the Surgeon General. DHHS Publ No. (CDC) 89-8411. Washington (DC): U.S. Gov Print Off; 1989.
- (12) Environics Research Group Ltd. Awareness of health hazards due to smoking. Toronto (ON): Environics Research Group Ltd; Dec 17, 1990.
- (13) Gallup Organization. Gallup poll, July 6–8, 1990. Princeton (NJ): Gallup Organization; July 1990.
- (14) Chapman S, Wong WL, Smith W. Self-exempting beliefs about smoking and health: differences between smokers and ex-smokers. *Am J Pub Health* 1993;83:215–9.
- (15) Cohn LD, Macfarlane S, Yanez C, Imai WK. Risk-perception: differences between adolescents and adults. *Health Psychol* 1995;14:217–22.
- (16) Nisbett R, Ross L. Human inference: strategies and shortcomings of social judgment. Englewood Cliffs (NJ): Prentice Hall; 1980.
- (17) Viscusi VK. Do smokers underestimate risks? *J Pol Economy* 1990;98:1253–69.
- (18) Viscusi WK. Smoking: making the risky decision. New York (NY): Oxford University Press; 1992.
- (19) Yamagishi K. When a 12.86% mortality is more dangerous than 24.14%: implications for risk communication. *Appl Cogn Psychol* 1997;11:495–506.
- (20) Black WC, Nease RF Jr, Tosteson AN. Perceptions of breast cancer risk and screening effectiveness in women younger than 50 years of age. *J Natl Cancer Inst* 1995;87:720–31.
- (21) Shiloh S, Saxe L. Perception of risk in genetic counseling. *Psychol Health* 1989;3:45–61.
- (22) Windschitl PD, Wells GL. Measuring psychological uncertainty: verbal versus numeric methods. *J Exp Psychol* 1996;2:343–64.
- (23) Diefenbach MA, Weinstein ND, O'Reilly J. Scales for assessing perceptions of health hazard susceptibility. *Health Ed Res* 1993;8:181–92.
- (24) Borland R. What do people's estimates of smoking related risk mean. *Psychol Health* 1997;12:513–21.
- (25) Sutton S. How ordinary people in Great Britain perceive the health risks of smoking. *J Epidemiol Community Health* 1998;52:338–9.
- (26) American Cancer Society. Survey of U.S. voter attitudes toward cigarette smoking. Washington (DC): American Cancer Society; Sept 9, 1993.
- (27) Eiser JR, Sutton SR, Wober M. Smoking, seat-belts, and beliefs about health. *Addict Behav* 1979;4:331–8.
- (28) Ayanian JZ, Cleary PD. Perceived risks of heart disease and cancer among cigarette smokers. *JAMA* 1999;281:1019–21.
- (29) Hoorens, V. Unrealistic optimism in health and safety risks. In: Rutter LD, Quine L, editors. The social psychology of health and safety: European perspectives. Aldershot (UK): Avebury; 1994. p. 153–74.
- (30) Weinstein ND, Klein WM, editors. Unrealistic optimism. Special issue of *J Soc Clin Psychol* 1996;15.
- (31) Quadrel MJ, Fischhoff B, Davis W. Adolescent (in)vulnerability. *Am Psychol* 1993;48:102–16.
- (32) Hahn A, Renner B, Schwarzer R. Perception of health risk: how smoker status affects defensive optimism. *Anxiety Stress Coping* 1998;11:93–112.
- (33) Segerstrom SC, McCarthy WJ, Caskey NH. Optimistic bias among cigarette smokers. *J Appl Soc Psychol* 1993;23:1606–18.
- (34) Slovic P. What does it mean to know a risk? Adolescents' perceptions of short-term and long-term consequences of smoking. *J Behav Decis Making*. In press 1999.
- (35) LoConte JS. Optimistic risk perceptions and external risk attributions among smokers: identifying dimensions of risk-minimization and their correlates [dissertation]. New Brunswick (NJ): Rutgers University; 1995.
- (36) Lynch BS, Bonnie RJ, editors. Growing up tobacco free: preventing nicotine addiction in children and youths. Washington (DC): Institute of Medicine; 1994.

NOTES

¹Unpublished bibliography on perceived invulnerability and optimistic biases about risk or future life events is available from the author.

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