

# Why (Cancer) Risk Communication Can Be Hard

Baruch Fischhoff

Effective risk communication uses audience members' time well by providing them with the information that they most need, in a form that they can easily comprehend. Accomplishing this task can be hard because of problems with both the transmitter and the receiver. The former must determine what is most worth saying. The latter must integrate that message with their often fragmentary mental models of the processes creating and controlling the risks. One strategy for improving communication is to use analytic methods for selecting the information to transmit, based on its criticality to recipients' decision making. A second strategy for improving communications is adapting the message to the cognitive processes of its recipients. Together, these strategies can reveal the limits to communication and how best to work within them. [Monogr Natl Cancer Inst 1999;25:7-13]

Understanding most risks has a qualitative and a quantitative component. Quantitatively, those exposed to a hazard need to know how big the threat is, in terms that allow them to evaluate its seriousness (compared with the costs of reducing it). Qualitatively, they need to know how the hazard can be controlled, in terms that allow them to select and implement appropriate actions as well as to detect changes in their circumstances. These two sets of information needs are interrelated. The magnitude of a risk should affect people's interest in its mechanisms. Conversely, an understanding of those mechanisms may make quantitative estimates more meaningful, by showing how the risk could be that big or small.

Like any good communication process, formulating an effective risk message begins by characterizing the information needs of its intended audience. A message should focus on the most critical facts that have yet to be understood. Then those facts need to be transmitted in a credible, comprehensible way. Accomplishing these goals requires a *normative* analysis of which facts are most worth knowing and a *descriptive* analysis of what people currently believe. The normative analysis should apply the best scientific knowledge about risk to the specific concerns of the target individuals. The descriptive analysis should apply the best scientific knowledge about human information processing to those individuals' specific needs. The resulting communication should be tested and the process continued, until audience members experience no more than the acceptable level of misunderstanding (1).

The next two sections of this paper discuss, in turn, communicating qualitative and quantitative information. Each process requires (a) normative analyses of what is worth knowing and (b) descriptive studies of what is worth saying. The concluding section considers the strategy of relying on informational messages to help people cope with serious risks.

## WHAT IS WORTH KNOWING

### Quantitative Information About Risks

Conceptually, determining quantitative information needs is straightforward.

1) Describe the decisions that audience members face. The conventional way to do that is with a decision tree, like that in Fig. 1. It begins with the options available and ends with the consequences whose probability of occurrence is affected by the choice of option. Between them lie uncertain events, whose outcome determines whether the consequences do, in fact, occur (2,3).

2) Summarize the target individuals' current perceptions of these decisions. Conventionally, these beliefs are represented as the subjective probabilities of the possible outcomes (e.g., the chances of true and false positives from a mammogram or of living various time periods with a chosen treatment). Individuals' values are represented by the perceived utility (or disutility) of experiencing the different consequences (or, equivalently, the acceptable trade-offs among them).

3) Identify the optimal choice implied by these judgments. This could be called the subjectively rational choice, in the sense of representing what people would choose if they made best use of their (possibly misinformed) beliefs.

4) Redo the analysis, replacing each subjective estimate, in turn, by the best available scientific estimate. For questions of fact, this step means changing the probabilities to ones informed by current science. For questions of value, this step means changing the utilities to ones informed by a full appreciation of what it means to experience the consequence (which might, mercifully, be unprecedented in many people's lives).

Replacing all model estimates with the best scientific estimates produces what could be called the objectively rational choice. (This use of "objective" recognizes that science always involves an element of judgment.) Those estimates whose replacement has the largest effect on choices are the logical foci of communication (i.e., they are the facts whose transmission matters most) (4). In Fig. 1, that choice might mean giving a more accurate feeling for the effectiveness of chemotherapy or the associated nausea. Or it might mean pointing to options or consequences that were neglected entirely (e.g., a new clinical trial, career changes).

Message content should proceed as far down the list of priorities as the communication opportunity allows. Inevitably, there are limits. Recipients may lack the time or cognitive capacity to process every fact that might help them—or the emotional capacity to deal with some specific facts. The communicator may not feel free to discuss some issues (e.g., effects on sexual performance, risks of professional misconduct). Thus, effective communication must be realistic about where people are coming from and about how far they can be taken.

Getting information out of people, regarding their current beliefs, involves much the same cognitive processes as getting

Correspondence to: Baruch Fischhoff, Ph.D., Department of Social and Decision Sciences, Department of Engineering and Public Policy, Carnegie Mellon University, Pittsburgh, PA 15213 (e-mail: baruch@cmu.edu).

© Oxford University Press

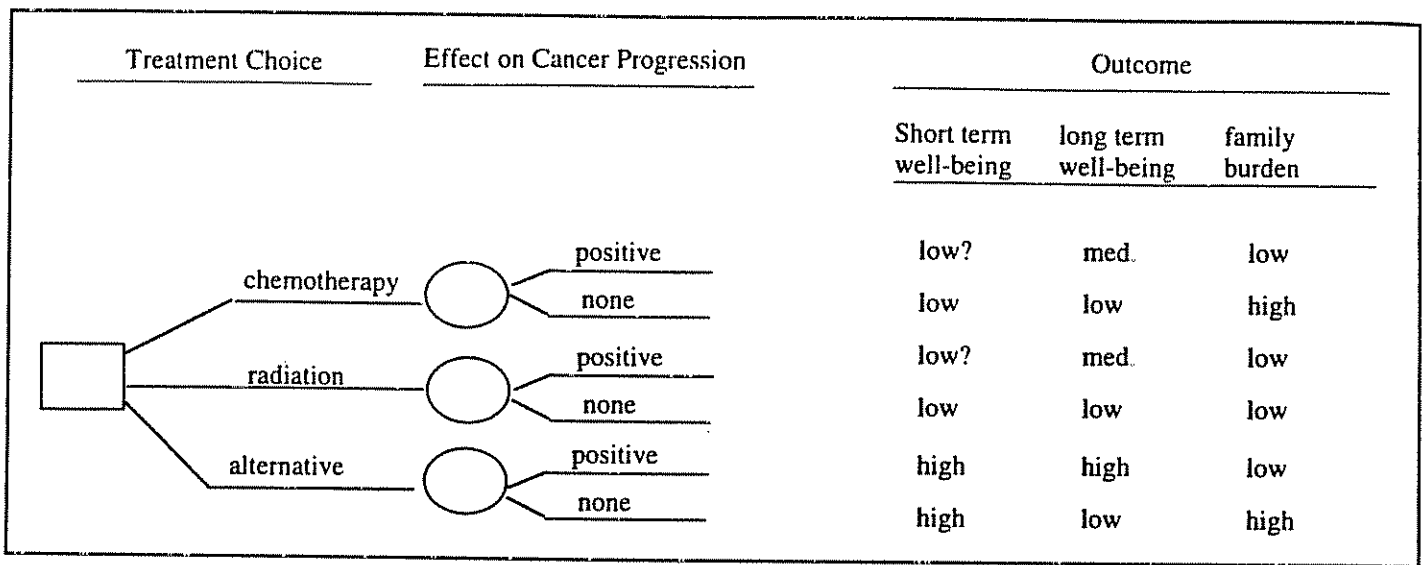


Fig. 1. A partial decision tree for cancer treatment. Actual values depend on specific case

information into them. As a result, it is a major topic of this paper. Although eliciting expert beliefs is left to other sources (5,6), it faces analogous cognitive issues. Identifying and integrating the full set of expertise relevant to an analysis often poses significant intellectual (and institutional) challenges. Nonetheless, that discipline is needed before communicators can responsibly demand people's attention, occupy the spot in their lives that might be filled by other (better) messages, or despair of their incompetence (for failing to learn from messages that were, in truth, not very good)

### Qualitative Information About Risk

Identifying qualitative information needs follows from identifying quantitative information needs. An influence diagram (7,8), like that in Fig 2, is created to show the determinants of each uncertain event in the decision tree. In it, each node represents a variable; an arrow means that the variable at the head depends on the one at the tail. Purely qualitative models "merely" assemble the relevant risk factors and the processes linking them—in a sufficiently rigorous way to allow running

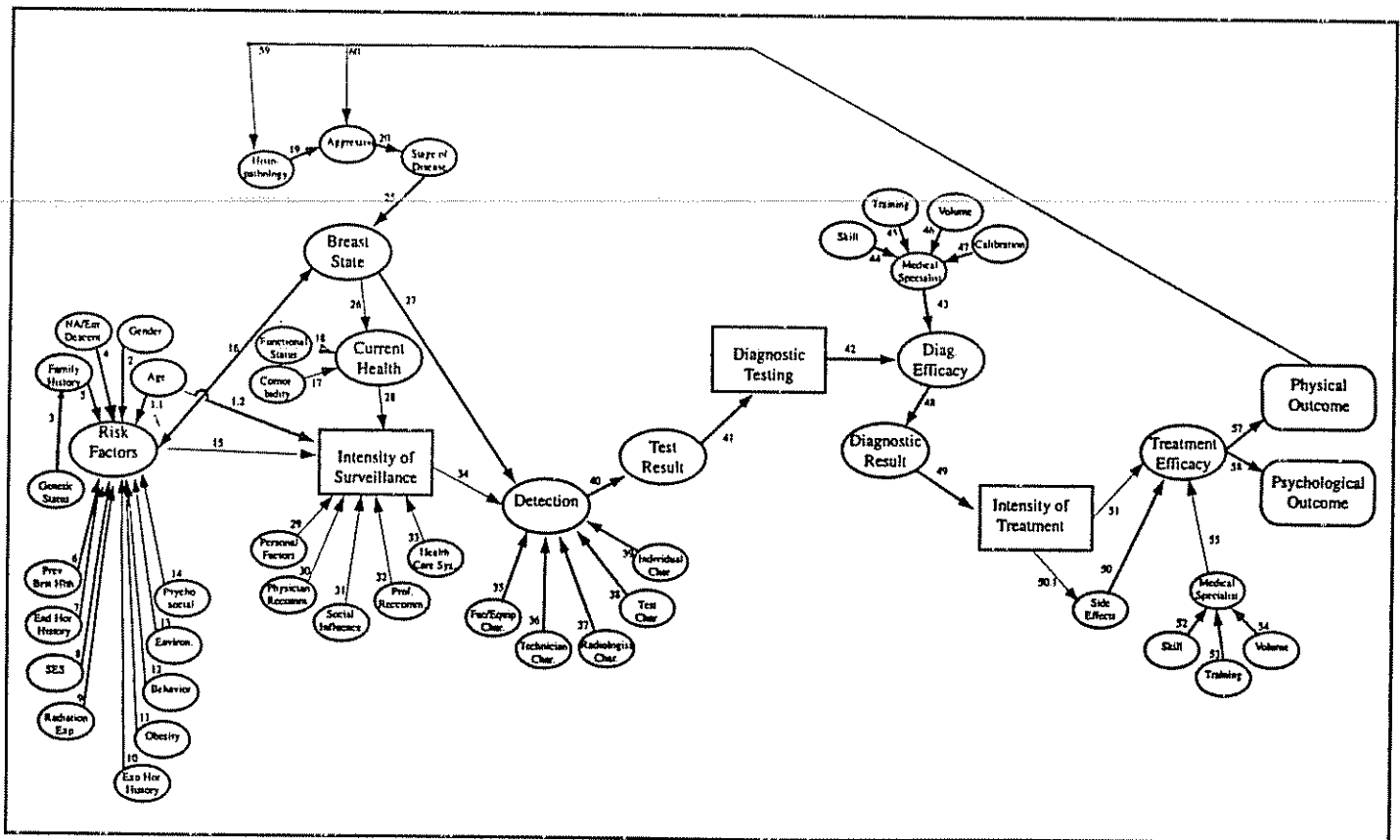


Fig. 2. An expert model for breast cancer diagnosis and treatment. Used with permission (45)

the numbers at some later day. Nonetheless, even the most qualitative modeling involves some rough quantification, to screen factors with weak influences or dubious scientific support.

Setting communication priorities follows the same logic as with quantitative information: (a) create influence diagrams relevant to the pending choices of target audience members; (b) conduct descriptive studies, identifying current beliefs about relationships in the diagram; (c) assess the risk judgments following from those beliefs; (d) identify the missing facts that would most improve those judgments; and (e) focus communications on them.

Those communications might involve correcting erroneous beliefs, perhaps by describing the strength of a relationship (e.g., "diet has only been weakly linked to breast cancer"), perhaps by explaining its rationale (e.g., "the body has complex metabolic processes, mediated by genes, activity, and environment, making it hard to tell what difference diet makes, especially with health problems whose natural progression is poorly understood"). Those communications might involve pointing to currently ignored relationships or refuting mistakenly accepted ones. Or they could provide background information, clarifying the picture as a whole (e.g., how hormones or breast mass change with age).

We call the result of a normative analysis an expert model and the result of descriptive research a mental model (1,9). In these terms, risk communication hopes to make lay people more like experts, in those ways that matter most to lay decisions. Because these terms may connote more than their literal intent, a few words of terminologic clarification are in order.

*Model* suggests a formal representation onto which one can map objects and operations. The expert model should allow such mapping; lay mental models often will not, especially for complex, novel problems (like many risks).

*Expert* refers to those who know most about each relationship in the model, without implying that any one expert is the best source for all topics nor that the community of experts knows everything.

*Lay* denotes the source of audience members' knowledge, not its extent. The experiences, curiosities, and distractions of everyday life can leave lay people clueless, self-educated, radically skeptical, or shrewdly observant. Often, lay people's indigent

technical knowledge (10) is essential for connecting general messages to specific circumstances.

## QUANTITATIVE LAY KNOWLEDGE

### Assessment

Assessing beliefs about uncertain contingencies means eliciting numeric judgments for the probabilities of clearly defined events. One common source of ambiguity is verbal quantifiers, such as "likely" and "rarely," whose numeric equivalent can vary by context and by individual (e.g., "likely" to rain versus "likely" to have a painful side effect) (11,12). Fortunately, eliminating it is straightforward: offer a linear scale, anchored at "0% = can't happen" and "100% = certain to happen," and label the appropriate tick marks with 10, 20, . . . , 90). If the probabilities might be very small, offer a log expansion of the section between 0% and 1%, as in Fig. 3. Such judgments have been elicited for many events, with diverse (and occasionally representative) populations of adolescents and adults. They require a little more work from respondents than do verbal quantifiers. As a result, they are less popular as a way to provide one's own beliefs but more popular as a way to receive others' beliefs (13). Their increased interpretability should justify a little respondent discomfort.

Two cautions are in order when probabilities are elicited with open-ended questions, as might occur with phone interviews. (a) People sometimes say "50," when they mean "fifty-fifty," indicating an inability or unwillingness to answer, rather than a numeric value (14). This tendency may be relatively common with poorly understood, negative events (the topics of many risk surveys). Fifty-fifty responses convey information about respondents' internal states; however, they exaggerate the perceived probability of unlikely events, if they are interpreted as numbers. (b) People's preference for integer responses also affects estimations of very low (and very high) probabilities. Such floor (or ceiling) effects are special cases of familiar psychophysical phenomena (15).

Resolving ambiguity in event descriptions is more complicated, insofar as there are many more words than kinds of numbers. One way to address it is the following process:

- 1) Ask people to think aloud as they answer a draft version of

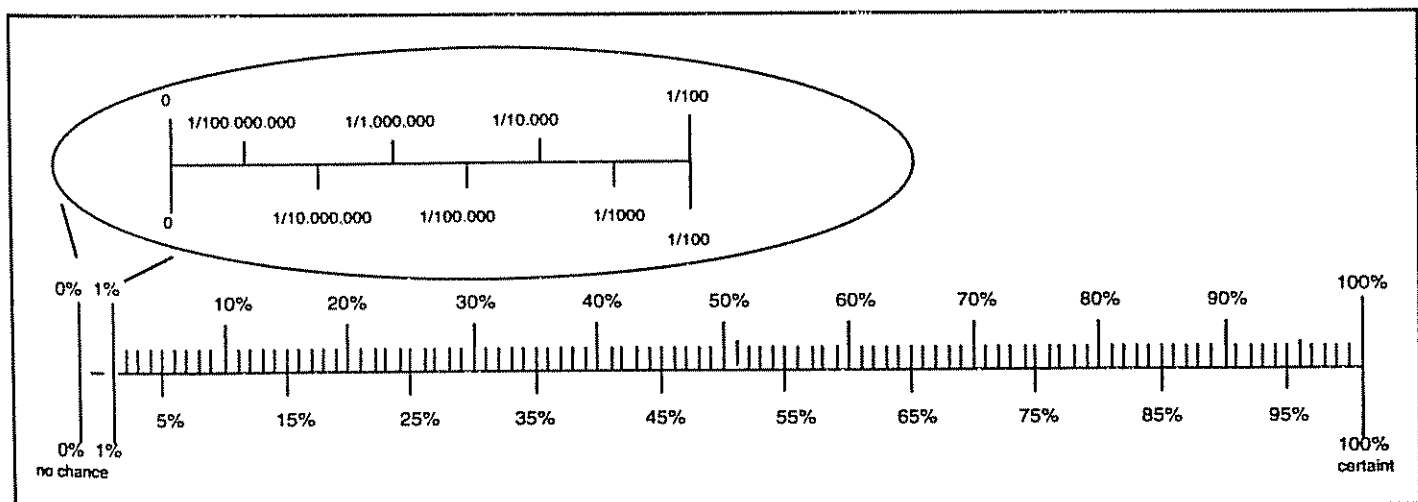


Fig. 3. A log-linear scale for eliciting probabilities. For the sake of balance, one might also expand the 99%–100% range. One variant uses a magnifying glass to highlight the very small probabilities (46).

the question (e.g., "What is the probability of getting chlamydia from having sex"?). Note each uncertainty raised or assumption made about its definition (e.g., "Do you mean the risk of doing it once or many times?" "Well, it's different for boys and girls").

2) Ask respondents to elaborate on each such concern to clarify its meaning and prompt other issues.

3) Code responses in terms of the risk factors that they reflect. Table 1 offers one general coding scheme for risk behaviors (16,17)

4) Draft a test question clearly specifying the needed details. Include factors relevant to lay people even if irrelevant to technical experts. If a question ignores an issue that respondents consider important, they may impute a value to it anyway.

5) Conduct tests to ensure that the fully specified question is understood as intended. That can be done with (a) think-aloud protocols (repeating steps 1 and 2), (b) manipulation checks (asking respondents to recall task details or make simple inferences from them), and (c) confirmatory tests, having subjects answer versions of the question that differ in each risk factor that was important to think-aloud subjects (to see if people really attend to the details that they say matter to them).

The final choice of wording may force some hard choices. For example, we might want to ask very general questions to cover a large set of events. However, doing so poses a quandary for respondents who make finer distinctions. To answer, they must either focus on some subset of the people and situations covered by the question (as defined by categories like those in Table 1) or compute a weighted average in their heads. Unlike probability scales, which can be developed once and then applied to many events, this procedure must be repeated for each event. Fortunately, the research on any term can then be applied whenever it occurs (as long as the target populations have similar linguistic norms). Thus, for example, McIntyre and West (18) have studied lay interpretations of safe sex, Turner et al. (19) have done so for drug-related behaviors, Leigh (20) has examined alcohol-related terms, and Morwitz (21) has reviewed verbs related to behavioral intentions (e.g., "will purchase"). A substantial amount of literature considers the meanings of "risk" itself (22-24).

## Improvement

The cognitive processes involved in expressing beliefs are also involved in creating them. Thus, similar design principles apply here. For example, communications should satisfy a person's need and preference for numeric quantifiers. Like response modes, information displays send signals. Thus, a log-linear display connotes that very small probabilities are possible and that one should take the trouble to distinguish among them. Its appropriateness is a matter of context and empirical testing.

Recommending numeric displays may seem odd, given the frequent lamentations over lay innumeracy (25,26). Although a full analysis is impossible here, one should note that studies showing lay trouble with numbers rarely speak to the present issue. These studies typically examine how people combine information from diverse sources, not how they understand individual facts. They focus on what people currently know, not on what they can learn. Furthermore, claims of lay incompetence frequently rest on untested assumptions (e.g., nonexpert risk judgments reflect differences in beliefs rather than in definitions of "risk"). Expert ambiguity can cause behavior that appears like innumeracy. For example, in the late 1970s, anecdotal evidence

Table 1. Coding framework for drinking and driving question

Framework element	Risk factor categories	Example variables
Behavior	Dose Amount Potency Method	Amount of alcohol consumed
Other behaviors	Risk buffers Risk amplifiers Time-related  Place-related	Amount of food eaten Other drugs consumed Night or day; day of the week  Where alcohol was consumed
Actor	Physical Cognitive  Social-psychological Material Spiritual Skill Character Age Sex Genetic history Status Luck Motivation Other	Tolerance to alcohol Awareness of effects of alcohol  Mood Wealth Faith Driving skill Responsible; mature
Context	Social General, cultural Family Peers, others Environmental	Drinking norms Family approval Peer approval Road conditions
Risk outcome	Social reactions Personal effects Physical Psychologic Cognitive-physiological Cognitive-psychological Material Accidents Lifestyle Complex Effects on others Behaviors Severity, type when measured	Get in trouble  Injury Worry, guilt Kill brain cells Can't think Lose car, lose license Get in a wreck while high Become a bum Get high Hurt your friends, family Use more, do heavier drugs

suggested public discomfort with probability-of-precipitation (PoP) forecasts; the problem, however, proved to be confusion over what forecasters meant by "precipitation," not "probability" (27). Finally, studies (28-30) showing lay innumeracy typically use highly structured tasks; whether providing the contextual cues of everyday life helps or hinders particular judgments is an empirical question.

Whatever the difficulties, communicating quantitative information is a matter of necessity. Effective decision making requires quantitative knowledge. We need to deliver it comprehensibly, so people need not guess about the size and probability of effects. We can hope that repeated exposure to standard displays of risk measures creates public understanding, as it has with other numbers now part of everyday life (e.g., PoP, recommended daily allowance).

Whatever quantifiers are used, the associated events must be clear. One possible strategy is using a controlled vocabulary. A push in this direction may come from the U.S. Food and Drug Administration's proposed warning label for over-the-counter

drugs (31). Although it avoids numbers (and has little empirical validation), this proposal could promote a common terminology for this large class of risks. An analogous (but quantitative) proposal has been advanced for automobile safety (32). All proposals need testing to confirm designers' intuitions.

Clear, consensual definitions may, however, not suffice if people cannot understand that kind of information. Such difficulties are the stock in trade of behavioral decision making (28,33), which studies lay understanding of uncertain processes that are neither self-evident nor routinely taught. Three examples may give a flavor for these problems and their possible treatment

1) The acceptability of very low probability risks can depend on how they are presented (e.g., relative versus absolute risk, frequency per year versus years between occurrences). The fairest presentation may be to show multiple perspectives, allowing recipients to triangulate and seek a rounded feeling for just how big the risk really is (34,35).

2) People have difficulty translating between single and multiple exposures to a hazard. Typically, they underestimate how quickly small risks (and small risk reductions) add up. Doing the math for them may be the only way to ensure that they get both perspectives (even if they cannot quite reconcile the two in their minds) (36,37).

3) People tend to anchor their beliefs on initial estimates (28). One protection is to present ranges rather than best guesses. The credibility of those ranges might be increased by explaining why the science is that uncertain (e.g., poor data, complex processes, competing claims). Such disclosure can prepare lay people for hearing competing arguments and seeing discrepant anecdotal evidence

## QUALITATIVE LAY KNOWLEDGE

### Assessment

Determining qualitative information needs begins by comparing lay and expert beliefs, regarding the factors creating and controlling risks. The sources of discrepancies can vary. Lay mental models may assign central roles to factors that technical experts have either rejected on the basis of evidence or neglected as a result of disinterest. Lay people may have insights that are lacking in expert models, drawing on a limited set of disciplines. For example, a modeling team might lack specialists in nutrition, social support, psychoneuroimmunology, or alternative medicine—all factors that might play roles in lay thinking, if not in the actual course of disease. For example, women's mental models of the recent controversy over mammography screening for women in their 40s seem focused more on their perceptions of health care finance than on scientific uncertainties (38).

Our approach to determining the elements of lay mental models parallels that for determining lay definitions of terms in quantitative estimates: (a) Ask individuals to, "Tell me what you have heard about X. Don't worry whether it is right or wrong. I'm just interested in what is on people's minds. The goal of our project is to help them to understand things better." (b) Ask them to elaborate on everything they say, and then elaborate on those elaborations. (c) After exhausting the topics that arise spontaneously, ask about domains in the expert model that should be common knowledge but have yet to be raised (e.g., "You haven't said anything about treatment, what can you tell me?"). (d) Code the interview in terms of the expert model, augmented, as

needed, with nonexpert concepts. (e) Conduct confirmatory tests to validate these mental models [e.g., structured surveys, problem-solving exercises (1,9)].

The beliefs that respondents express can be characterized in terms of prevalence (which issues occupy people), accuracy (where do they have expertise), calibration (how appropriate is their confidence in their beliefs), co-occurrence (which ensembles of beliefs must be addressed together), and content (what is the substance of those beliefs)

### Improvement

The communications following from these analyses address those mental model elements most critical to the decisions facing audience members. These messages may present the entire expert model, perhaps with minimal detail (when audiences know nothing), perhaps with great detail (when audiences know a lot but cannot keep the pieces straight). Or messages may focus on specific facts, perhaps addressing "bugs" that undermine otherwise solid mental models, perhaps providing a stopgap for those knowing little. Four examples from our own work may illustrate these possibilities:

1) The carcinogenic potential of electromagnetic fields is a recurrent public concern. Our descriptive research found that most citizens knew so little that they needed basic orientation, whereas a few had much, albeit, somewhat fragmentary knowledge. Our brochure was tiered, so that it could be read at several levels of detail (for readers with varying expertise and interests). It made a special effort to debias common lay misconceptions regarding how quickly electromagnetic fields decline with distance and how they can be shielded. We tried to clarify public controversies by explaining why scientists disagree about electromagnetic fields. Members of each camp reviewed how we represented their positions. We have sold (at cost) a couple hundred thousand copies of this brochure and would like to think that it has helped to focus the national debate (39).

2) Space missions far from the sun or requiring concentrated power currently must use nuclear energy sources. After seeing citizen opposition to the Galileo shot (to Jupiter and beyond), we conducted a series of descriptive studies, drawing most participants from a local conservation group. They were found to have (a) better elaborated mental models for the effects of potential problems than for their sources, (b) a tendency to confuse radiation and radioactivity, and (c) coherent beliefs (and preferences) regarding alternative designs for response to orbital failure. The research led to a brochure that left test subjects better informed about and more favorable toward the technology than did the National Aeronautics and Space Administration's (NASA) brochures (40,41). Our research did not seem to influence NASA's communications, although the agency did refer some journalists to us when the Cassini shot generated similar controversy.

3) In the late 1980s, the U.S. Environmental Protection Agency (EPA) began an ambitious campaign to reduce domestic radon exposures, which were thought to be a major source of lung cancer (especially in homes with smokers). In an unusual (and laudatory) move, EPA evaluated its intervention. Unfortunately, little increase in testing or remediation was done. Our descriptive studies (9) suggested that, although much of EPA's message had gotten through, citizens' mental models often had a major bug: Reasonably but erroneously, they believed that radon meant permanent contamination. If so, then there was

little point in testing. The revised EPA *Citizen's Guide to Radon* addressed this concern. In this case, the relevant science is easy to explain: Radon decays very rapidly. As a result, a small amount can damage your lungs. However, it is also gone quickly. So the problem vanishes if homeowners can keep additional radon from coming into their houses.

4) Methylene chloride, used as paint stripper, is one of many suspected carcinogens used in the home. Consumers' exposure depends on their usage patterns. Unfortunately, the package labels that might shape their behavior lack clear wording and organization. By use of a combination of formal modeling and mental models interviews, we identified supply curves for usage instructions, prioritizing message content. The model allows different assumptions regarding how many instructions users will read and how full their compliance will be—given their mental models and perceived need to get the job done (42,43).

Each such application must consider the particulars of that cancer risk. Yet, each can take advantage of common components: the science (e.g., indoor air circulation, examples 2 and 4), the perceptions (e.g., confusing radiation and radioactivity, examples 2 and 3), or the medium (e.g., brochure design, examples 1, 2, and 3). As a result, one challenge to the managers of communication programs is creating opportunities for such modular design. My colleagues and I hoped to advance this goal in the area of breast cancer by creating the overall expert model of Fig 2 and by conducting mental model interviews on the many topics in its domain. The voluminous literature on science education provides advice on conveying many specific processes (e.g., hormones, doubling rates). The expert model is intended to facilitate mapping that research into communication-relevant terms.

## CONCLUSION

Cancer risk communication can be difficult because people are imperfect. Their knowledge of the relevant science is often fragmented and inaccurate. Neither their education nor their everyday experience ensures the numeracy or scientific literacy demanded by these complex, dynamic, and uncertain processes. Even when they have the cognitive resources, people may care too little to think at all about distant risks; they may care too much to think clearly about imminent ones.

In other cases, though, when communication fails, the difficulty does not lie with the receivers. Rather, the transmitters have failed to understand their audience. The transmitters repeat what the receivers know and neglect what they do not. Transmitters patch minor holes and neglect major ones. They use jargon or loaded language. They speak before they listen and undermine their credibility.

Informing the public should follow the same conversational norms as informing children, patients, or students: Figure out which facts have the greatest value to the audience; then relay those facts clearly. Sometimes this step will mean a brief statement; sometimes it will require providing needed context. Explicit analysis and empirical testing are needed, when we are too distant from our audience to get messages right the first time or to evaluate our success. The present approach uses decision-theory formalisms to create a platform capable of integrating results from diverse risk sciences (into the expert model); it uses behavioral science techniques to characterize lay beliefs (as mental models); it draws on research in judgment and science education to address critical gaps.

Creating a computable expert model can impose valuable discipline, even when no numbers are run, by forcing the scientists involved to think through the relationships among their fields. It can also help scientists play more constructive roles in the communication process. Creating a computable expert model means listening to the scientists first—always a good step in communication. It decomposes the communication task, so that it seems more feasible (especially for scientists who would otherwise have but a blurred image of a hysterical public). The computable expert model also puts scientists' personal interests in a broader setting, providing a way to coordinate risk research programs and focus them on communication (i.e., public) needs (44).

Given the emotions surrounding cancer risks, greater formalization may seem like a strange strategy. Clearly, cancer risk communication is not just about facts. The interpretation of a message may cause and be affected by powerful emotions. The hope here is to get the information part right. Doing so allows people to be as cognitive as they want to be in their decision making. It may encourage them to think more before they act, by making thought seem more tractable. Just as undue emotion can swamp cognition, ineffective cognition can generate emotion—as people despair of thinking their way through to answering their problems.

## REFERENCES

- (1) Fischhoff B, Bostrom A, Quadrel MJ. Risk perception and communication. In: Detels R, McEwen J, Omenn G, editors. *Oxford textbook of public health*. London (UK): Oxford University Press; 1997. p. 987-1002.
- (2) Hammond JS, Keeney RL, Raiffa H. *Smart choices: a practical guide to making better decisions*. Boston (MA): Harvard Business School Press; 1999.
- (3) Raiffa H. *Decision analysis: introductory lectures on choices under uncertainty*. Reading (MA): Addison-Wesley; 1968.
- (4) Merz JF, Fischhoff B. Informed consent does not mean rational consent. Cognitive limitations on decision-making. *J Leg Med* 1990;11:321-50.
- (5) Fischhoff B. Eliciting knowledge for analytical representation. *IEEE Trans Syst Man Cybern* 1989;13:448-61.
- (6) Morgan MG, Henrion M. *Uncertainty: a guide to dealing with uncertainty in quantitative risk and policy analysis*. New York (NY): Cambridge University Press; 1990.
- (7) Clemon RT. *Making hard decisions: an introduction to decision analysis*. Boston (MA): PWS-Kent; 1991.
- (8) Howard RA. Knowledge maps. *Manage Sci* 1989;35:903-22.
- (9) Bostrom A, Fischhoff B, Morgan MG. Characterizing mental models of hazardous processes: a methodology and an application to radon. *J Soc Issues* 1992;48:85-100.
- (10) Brokensha DW, Warren DM, Werner O. *Indigenous knowledge: systems and development*. Washington (DC): University Press of America; 1980.
- (11) Budescu DF, Wallsten TS. Processing linguistic probabilities: general principles and empirical evidence. In: Busemeyer JR, Hastie R, Medin DL, editors. *Decision making from a cognitive perspective*. New York (NY): Academic Press; 1995. p. 275-318.
- (12) Merz JF, Druzdzel MJ, Mazur DJ. Verbal expressions of probability in informed consent litigation. *Med Decis Making* 1991;11:273-81.
- (13) Erev I, Cohen BL. Verbal versus numerical probabilities: efficiency, biases and the preference paradox. *Organ Behav Hum Decis Processes* 1990;45: 1-18.
- (14) Fischhoff B, Bruine de Bruin W. Fifty/fifty = 50? *J Behav Dec Making* 1999;12:149-63.
- (15) Poulton EC. *Bias in quantifying judgment*. Hillsdale (NJ): Lawrence Erlbaum; 1989.
- (16) Fischhoff B. The real world: what good is it? *Organ Behav Hum Decis Processes* 1996;65:232-48.
- (17) Quadrel MJ. *Elicitation of adolescents' risk perceptions: qualitative and quantitative dimensions [dissertation]*. Pittsburgh (PA): Carnegie Mellon University; 1990.

- (18) McIntyre S, West P. What does the phrase "safer sex" mean to you? Understanding among Glaswegian 18 year olds in 1990. *AIDS* 1992;7: 121-6.
- (19) Turner CF, Lessler JT, Gfroerer JC, editors. *Survey measurement of drug use: methodological studies*. Rockville (MD): National Institute on Drug Abuse; 1992.
- (20) Leigh BC. In search of the Seven Dwarves: issues of measurement and meaning in alcohol expectancy research. *Psychol Bull* 1989;105: 361-73.
- (21) Morwitz V. Behavioral intentions. In: Armstrong JS, editor. *Handbook of forecasting principles*. Norwell (MA): Kluwer; 1999.
- (22) Fischhoff B, Slovic P, Lichtenstein S, Read S, Combs B. How safe is safe enough? A psychometric study of attitudes toward technological risks and benefits. *Policy Sci* 1978;8:127-52.
- (23) National Research Council. *Understanding risk: informing decisions in a democratic society*. Washington (DC): National Academy Press; 1996.
- (24) Slovic P. Perceptions of risk. *Science* 1987;236:280-5.
- (25) Breyer SG. *Breaking the vicious circle: toward effective risk regulation*. Cambridge (MA): Harvard University Press; 1993.
- (26) Wildavsky A. *Searching for safety*. London (U.K.): Transaction Books; 1988.
- (27) Murphy AH, Lichtenstein S, Fischhoff B, Winkler RL. Misinterpretations of precipitation probability forecasts. *Bull Am Meteorolog Soc* 1980;61: 695-701.
- (28) Kahneman D, Slovic P, Tversky A, editors. *Judgments under uncertainty: heuristics and biases*. New York (NY): Cambridge University Press; 1982.
- (29) Plous S. *The psychology of judgment and decision making*. New York (NY): McGraw-Hill; 1993.
- (30) von Winterfeldt D, Edwards W. *Decision analysis and behavioral research*. New York (NY): Cambridge University Press; 1986.
- (31) Department of Health and Human Services. Food and Drug Administration. *Over-the-counter human drugs; proposed labeling requirements*. Federal Register 1997 Feb 27; 9024-62.
- (32) National Research Council. *Shopping for safety: providing consumer automotive safety information*. Washington (DC): National Academy Press; 1996.
- (33) Dawes R. *Rational choice in an uncertain world*. San Diego (CA): Harcourt Brace Jovanovich; 1988.
- (34) Kahneman D, Tversky A. Choices, values, and frames. *Am Psychol* 1984; 39:341-50.
- (35) Stone ER, Yates JF, Parker AM. Effects of numerical and graphical displays on professed risk-taking behavior. *J Exp Psychol Applied* 1997; 3:243-56.
- (36) Linville PW, Fischer GW, Fischhoff B. AIDS risk perceptions and decision biases. In: Pryor JB, Reeder GD, editors. *The social psychology of HIV infection*. Hillsdale (NJ): Lawrence Erlbaum; 1993. p. 5-38.
- (37) Slovic P, Fischhoff B, Lichtenstein S. Accident probabilities and seat-belt usage: a psychological perspective. *Accident Analysis Prev* 1978;10: 281-5.
- (38) Schwartz LM, Woloshin S, Byram SJ, Sox HC, Fischhoff B. Which age is right? Women's reactions to the mammography screening debate [abstract]. *J Gen Intern Med* 1998;13(suppl):107.
- (39) Morgan MG. *Fields from electric power*. Pittsburgh (PA): Carnegie Mellon University, Department of Engineering and Public Policy; 1995.
- (40) Maharik M, Fischhoff B. Public views of using nuclear energy sources in space missions. *Space Policy* 1993;9:99-108.
- (41) Maharik M, Fischhoff B. Contrasting perceptions of risks of using nuclear energy sources in space. *J Environ Psychol* 1993;13:243-50.
- (42) Fischhoff B, Riley D, Kovacs D, Small M. What information belongs in a warning? A mental models approach. *Psychol Marketing* 1998;15: 663-86.
- (43) Riley DM. *Human factors in exposure analysis for consumer paint-stripper use* [dissertation]. Pittsburgh (PA): Carnegie Mellon University; 1998.
- (44) Fischhoff B, Downs J, Bruine de Bruin W. Adolescent vulnerability: a framework for behavioral interventions. *Appl Prevent Psychol* 1998;7: 77-94.
- (45) Byram S. *Breast cancer and mammogram screening: mental models and quantitative assessments of beliefs* [dissertation]. Pittsburgh (PA): Carnegie Mellon University; 1998.
- (46) Woloshin S, Schwartz LM, Byram S, Fischhoff B, Welch HG. Scales for assessing perceptions of event probability: a validation study. *Med Dec Making* 1998;14:490-503.

