Frequency or Probability? A Qualitative Study of Risk Communication Formats Used in Health Care

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Med Decis Making 2001; 21; 459

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Background**. The communication of probabilistic outcomes is an essential aspect of shared medical decision making. **Methods**. The authors conducted a qualitative study using focus groups to evaluate the response of women to various formats used in the communication of breast cancer risk. **Findings**. Graphic discrete frequency formats using highlighted human figures had greater salience than continuous probability formats using bar graphs. Potential biases in the estimation of risk magnitude were associated with the use of highlighted human figures versus bar graphs and the denominator size in graphics using highlighted human figures. The presentation of uncertainty associated with risk estimates caused some to loose trust in the information, whereas others were accepting of uncertainty in scientific data. **Conclusion**. The qualitative study identified new constructs with regard to how patients process probabilistic information. Further research in the clinical setting is needed to provide a theoretical justification for the format used when presenting risk information to patients. **Key words:** risk perception; graphical displays; breast neoplasm; health education; patient education; decision making. **(Med Decis Making 2001;21:459–467)

The meaningful communication of numeric risk information has an important role in the practice of clinical medicine. This is especially so when a patient chooses to take an active role in a complex decision where risks and benefits must be considered. For example, the decision about use of postmenopausal hormone replacement therapy involves balancing the benefits of reducing osteoporosis fractures against the possible increased risk of breast cancer.[1,2] Counseling patients about cancer screening interventions and informed consent for medical procedures or entrance to clinical trials also involve the presentation of risk and benefit information.[3-5] Decision aids are interventions developed to assist patients with the decision-making process for complex decisions.[6] An essential component of most decision aids is the presentation of tailored, numeric outcome information associated with various medical options. However, little empirically derived guidance exists with regard to what formats to use in presenting numeric risk information.

The interpretation of numeric risk information is subject to a broad range of biases.[7-9] A bias can occur when risk is presented with a positive versus negative frame,[10-12] with gains versus losses,[13,14] or with the use of a relative risk, absolute risk, or number-needed-to-treat format.[15-18] Graphic formats are found to aid human processing of quantitative information[19-22] and have been used to supplement numeric risk information in the communication of health risks.[23] Prior studies have demonstrated that risk format may influence patients' health care decisions.[24-29] However, basic questions remain with regard to how and why given elements of risk format influence patients' risk perceptions and reasoning. The objectives of this study are to generate hypotheses about the preferences, perceptions, and potential biases associated with formats used in the communication of numeric risk in the clini-

Received 22 June 2000 from the Department of Medicine, Medical College of Wisconsin, Milwaukee, and the Center for Health Services Management and Research and Veterans Administration Medical Center, Lexington, Kentucky. Revision accepted for publication 13 June 2001. This article was presented at the 1998 meeting of the Society of Medical Decision Making in Boston, Massachusetts, and supported by a grant from the National American Cancer Society (CCCDA-97-3).

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cal setting. Frequency and probability formats are explored both with and without the use of graphic displays. The study uses the clinical scenario of women being presented with breast cancer risk as a model for understanding responses to risk formats generally. We also explore the response to the presentation of uncertainty associated with risk reduction estimates using the clinical example of breast cancer mortality risk reduction in mammography.

Methods

STUDY APPROACH

We used a qualitative methodology consisting of focus groups. Qualitative methods are generally valuable in health services research when the investigators wish to remain open to the development of new constructs, theories, and hypotheses with regard to the topic in question.[30-32] A focus group is a structured interview of a group of subjects on a given topic led by a moderator. Subjects are chosen for whom the topic in question is relevant and who share some characteristics with each other. Focus groups are designed to encourage group interaction with the goal of obtaining a richer data set than might develop from individual interviews.[33-35] Focus groups have been used in many studies of health behavior including physician attitudes toward risk communication tools and shared decision making.[36-39]

SAMPLING METHOD

Subjects were recruited over the telephone by a professional qualitative research firm that used methods of random sampling of listed telephone numbers supplemented by convenience community sampling. Subjects were recruited from 2 Wisconsin communities—Milwaukee and Green Bay—to assist in sampling from different ethnic and socioeconomic groups. Women between the ages of 40 and 65 years, who did not work in market research, advertising, or in a doctor's office or hospital, were eligible for participation. Segmented samples were used to achieve homogeneity in age, educational level, and community of residence, but they were heterogeneous with respect to race. The goal of recruitment was to reach a sample size of 10 to 12 subjects, the upper limit of recommended focus group size.[33,35]

SETTING

The focus groups were held in the evening in qualitative research facilities in the community of the participants (i.e., Milwaukee or Green Bay metropolitan area). Focus groups were led by a professional focus group moderator who was not a research investigator. The role of the investigators included the development of a focus group guide that was used by the moderator in leading the sessions. Each of the focus groups met for 2 hours and was audiotaped and videotaped. One study investigator (MMS) observed all groups behind a 1-way mirror. Subjects were informed that they were being observed through the 1-way mirror as well as audiotaped and videotaped prior to the session. Patients were remunerated $40.00 for their participation. Development of the focus group discussion guide was based on a review of the literature on risk communication and risk perceptions. The domains discussed in the focus groups included formats used to convey numeric risk with and without graphic illustrations, variation in the time frame use to present risk, and concepts of conveying uncertainty associated with risk estimates. Visual aids were used to illustrate various graphic formats of risk presentation (Figures 1-6). A graphic of highlighted human figures was used to illustrate the frequency numeric format. A bar graph was used to illustrate the probability numeric format. Numeric values (such as 0.9/10 or 9%) were used to label the human figure graphics and bar graphs, respectively. A line graph was used to present a point estimate and associated confidence intervals of the breast cancer mortality relative risk reduction associated with mammography in women 40 to 49 years old (Figure 6). The risk estimates used for the discussion and graphic illustrations were based on those of a 50-year-old woman without major breast cancer risk factors as calculated by the Gail model.[40] Graphics primarily used black, white, and the color red (Figures 1-6).

METHODS FOR COLLECTING AND ANALYZING INFORMATION

A content analysis was used to interpret the findings and develop themes from the data. In content analysis, the investigator categorizes words and phrases. The investigators then attempt to find meaningful relationships between the categories that help to address the research questions.[41] Written verbatim transcripts of the audiotapes were prepared to ensure the dependability (reliability) of the findings. Investigators reviewed the transcripts and generated and coded themes that emerged from the data. The focus group served as the fundamental unit of analysis. The credibility (internal validity) of the findings was supported by comparing emerging themes between focus groups. Themes reported were generated independently in at least 2 of the focus groups unless otherwise indicated in the findings. Interanalyst comparisons were made to increase the dependability of the data. Two investigators (MMS and CAM) came to independent conclusions with regard to the emergent themes. A 3rd investigator (ABN) then reviewed the transcripts and interpretations and assisted in the final analysis. The qualitative analysis software program QSR NUD*IST 4.0 (Nonnumerical Unstructured Data Indexing Searching and Theorizing) was used to assist in the analysis.[41] Review of the videotapes was undertaken to study group dynamics on topics in which there were many opinions expressed and to confirm the identity of a response when unclear on written transcripts. Field notes taken by the observing investigator (MMS) were used to generate initial ideas with regard to themes from the data.

Table 1 Demographic Characteristics of Focus Group Participants

Focus Groups	*n*	College Graduate	Age in Years	Race
1	10	No	40-49	White (8) Native American (2)
2	10	No	50-65	White (10)
3	10	Yes	40-49	White (8) Black (2)
4	11	Yes	50-65	White (8) Black (3)

Note: In focus group 1, 4 subjects had a high school degree and 6 subjects had some college or technical school education. In focus group 2, 4 subjects had a high school degree and 6 subjects had some college or technical school education.

Findings

STUDY POPULATION

The study included 4 focus groups, each consisting of 10 to 11 participants. Each group was homogeneous with regard to age (40-49 years vs. 50-65 years), education (less than a 4-year college education vs. 4-year college degree or more education), and community of residence (Milwaukee or Green Bay metropolitan area). However, groups were diverse with regard to race. Of the total cohort, 83% were white, 12% were black, and 5% were Native American (Table 1).

FREQUENCY AND PROBABILITY FORMATS OF RISK COMMUNICATION

The focus groups first explored the use of frequency (such as the risk of 1 in 10) and probability (such as a risk of 10%) formats without the use of graphic displays. Themes were developed identifying a set of attributes of each format. Attributes of the frequency format included ease of interpretation, simplicity, and the ability to provide a human contextual quality in the graphics. Attributes of a percentage format included an association with personal risk estimation and a mathematical quality. The following quotation illustrates the dichotomy in attributes identified between these formats:

> To me, percentages are math. One in 10 is people oriented.

One theme identified was concern with regard to the reliability of data when presented in a frequency format with a low denominator. Subjects questioned the sample size from which the data were drawn when a denominator of 10 was used, as illustrated in the following quotation:

> I think when someone gives numbers . . . that's just a percentage of people that they got this data from, there's masses of people and 20 people they probably used for the survey, and I can't base my life on that.

Another theme identified was the difference in interpretation of frequency compared to probability formats with regard to the personal relevance of the data presented. Some subjects conveyed the tendency to attribute risk to others, perhaps contributing to an optimistic bias, when a frequency format was used, as illustrated in the following quotation:[42]

> You could always tend to say, "It's not going to be me." One out of 10 . . . I'm going to be 1 of the 9.

Although a general level of comfort with both frequency and probability formats was expressed, questions with regard to the meaning of each format were raised in the lower education groups. For example, when presented with a risk of 1 in 10, one subject asked whether she was supposed to identify with the 1 in 10 or with the remaining 9 out of 10. A 2nd subject was un-

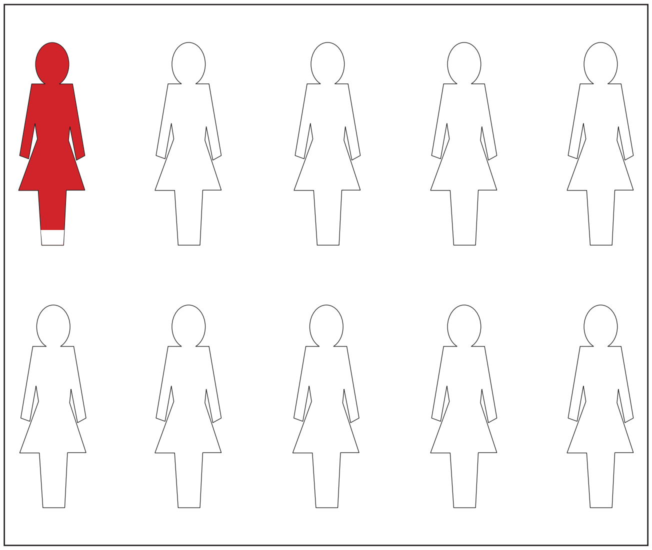

Figure 1. *Highlighted human figures used to present a lifetime risk of breast cancer for a 50-year-old woman. The lifetime risk of 9% is portrayed in a frequency format with a denominator of 10.*

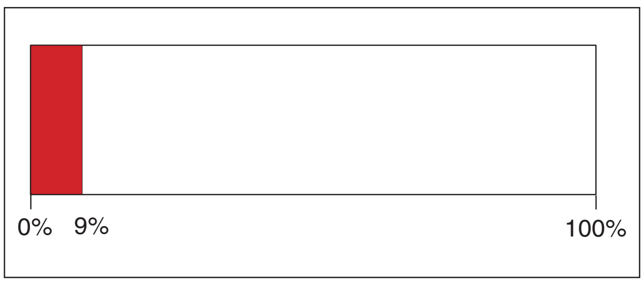

Figure 2. *Bar graph format used to convey lifetime risk of breast cancer for a 50-year-old woman.*

certain how to interpret information such as "your risk is 10%," asking "10% of what?"

GRAPHIC DISPLAY OF RISK

A consistent theme in our analysis was that frequency graphics using human figures were easy to identify with, were understandable, and conveyed a meaningful message. The human figures added contextual meaning to the numeric information presented because of the depiction of a person, and more specifically a woman, in the graphics. In contrast, bar graphs were perceived as analytical, as difficult to understand, and as having less impact. This contrast is conveyed in the following quotation:

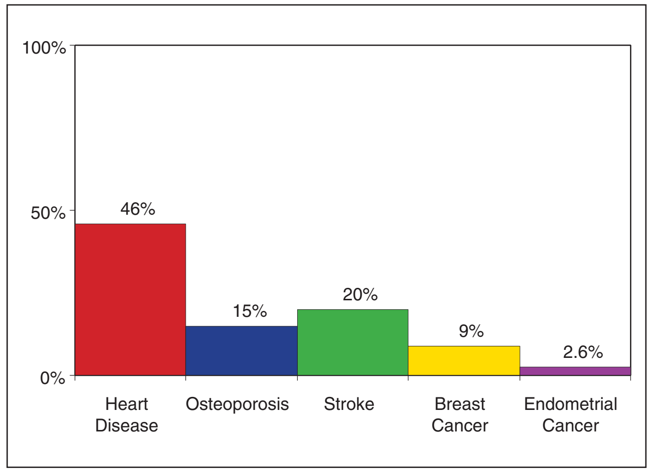

Figure 3. *Vertical bar graph format used to convey comparative lifetime risks for a 50-year-old woman including the risk of heart disease, osteoporosis, stroke, breast cancer, and endometrial cancer.*[40,59]

> The stick people are . . . people oriented. . . . It's visual . . . when you're looking at it you're seeing people compared to seeing a percentage.

A theme with regard to a risk magnitude bias associated with graphic format was generated from the discussion in our group of younger, less-educated women. Subjects in this group perceived a breast cancer lifetime risk of 9% to be higher when conveyed with human figure representations (Figure 1) compared to a bar graph (Figure 2).

A major theme identified in all 4 groups was the power of bar graphs to depict comparative risk information, such as the risk of heart disease, osteoporosis, stroke, breast cancer, and endometrial cancer (Figure 3). Even those who favored a human figure representation for the presentation of a single risk estimate found the bar graph to be a helpful format for the comparison of multiple risks, as illustrated in the following quotation:

> This [comparative risk bar graph] is more complicated than the stick people, but it is a very simplistic way of showing us more information.

A broad consensus was found with regard to a preference for a vertical (Figure 3) over a horizontal (not shown) orientation of bar graphs for the display of comparative risk information.

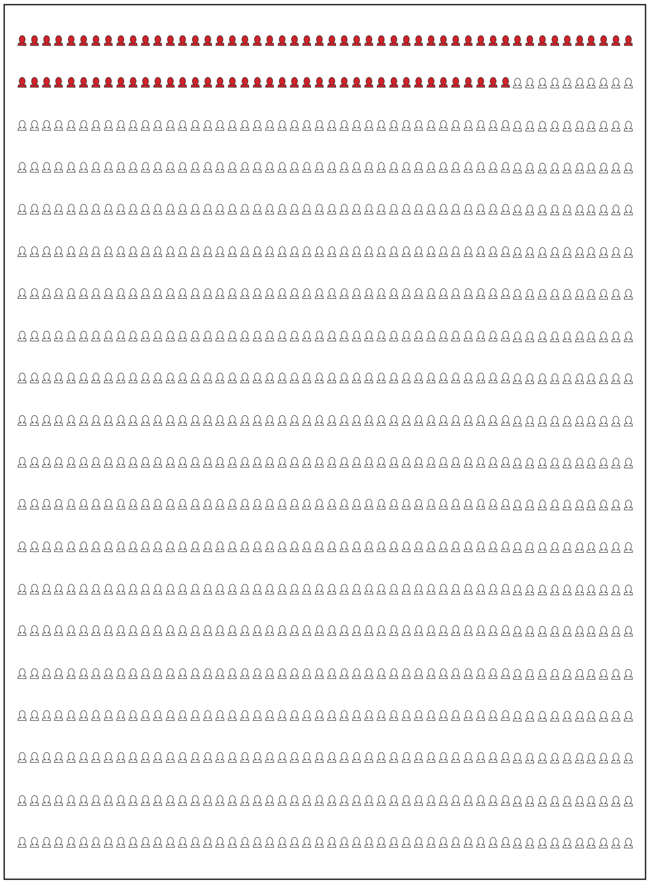

Figure 4. *Highlighted human figure format used to convey lifetime risk of breast cancer for a 50-year-old woman using a denominator of 1000 and consecutive highlighting of figures.*

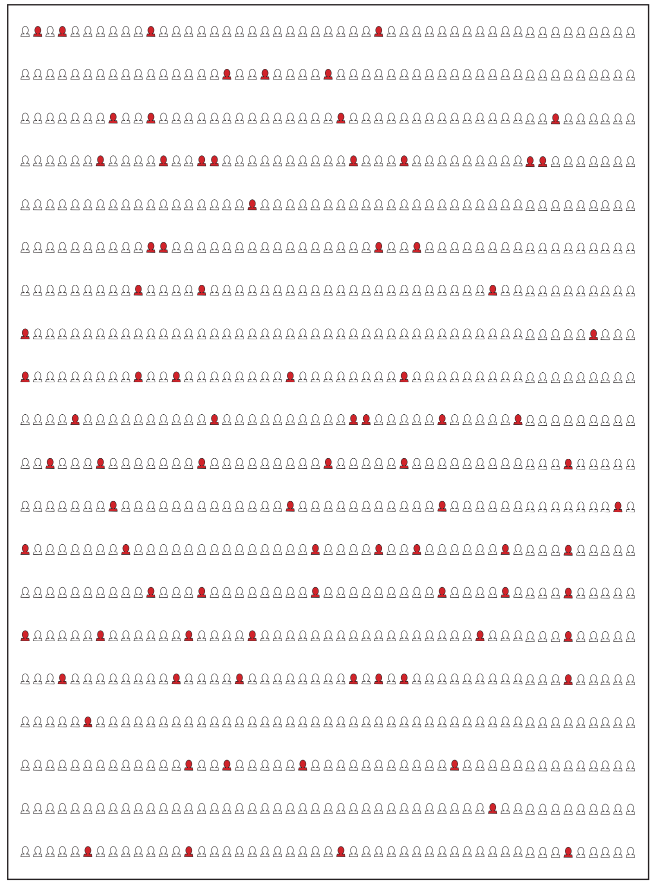

Figure 5. *Highlighted human figure format used to convey lifetime risk of breast cancer for a 50-year-old woman using a denominator of 1000 and random highlighting of figures.*

DENOMINATOR SIZE AND PATTERN OF HIGHLIGHTING IN FREQUENCY FORMATS

A theme with regard to the association between perceived risk magnitude and denominator size in a frequency graphic was identified (Figures 1 and 4). Graphics with larger denominators were perceived as depicting risk of lower magnitude. Subjects focused on the denominator, noting that more figures were presented without disease when the larger denominators were used (i.e., 100 or 1000 compared to 10). A dissenting opinion was voiced by 1 subject in our younger, more-educated group, who felt that the graphic with random highlighting of the numerator in the 90/1000 frequency conveyed a greater possibility of disease than graphics with lower denominators or consecutive highlighting of figures.

A theme identified in all 4 groups was that the frequency graphics with lower denominators had the positive attributes of simplicity, directness, and ease of interpretation, as illustrated by the following quotations:

> I like this one [denominator of 10] only because I think it's very simple. Everybody can understand it. One out of 10 and your chance is that.
>
> For me, it's [denominator of 10] the simplest one, because I'm going to read it. . . . I can visualize, I can see it and I can then go on and ask the questions that I want or seek out other information.

Another theme identified in all 4 groups was that random highlighting of the numerator in frequency graphics was difficult to process cognitively compared to consecutive highlighting (Figures 4 and 5). Although the concept of conveying random occurrence was recognized by some, it was cognitively difficult to appreciate the magnitude of the risk presented with the randomly highlighted format, as illustrated in the following quotation:

When you look at that, you can understand that it's random but you can't understand the percentages unless you sit there and count all the red dots.

TIME FRAME OF RISK INFORMATION

Themes with regard to the time frame over which risk estimates are presented varied with respect to age and educational level. Subjects across all 4 groups had least interest in annual risk presentation because of the transient and recurring nature of risk in that time frame, as illustrated by the following quotation:

> A year, and then what do you do . . . you have to go back and figure out for the next year and the next year.

However, a younger, more-educated subject noted the value of an annual risk estimate in conveying the risk of a new cancer between screening intervals. A 2nd subject in the older, more-educated group noted that she was reassured by the low value of an annual risk estimate.

Younger women (40-49 years) generally preferred a 10-year time frame because of the construct of a decade as a time frame in which one commonly makes plans in life, as illustrated by the following quotation:

> I would want to know by 10 years because I can visualize myself in 10 years. I can relate to it. I have plans and things to do in 10 years. But I don't know how to view beyond that.

Lifetime risk estimates were preferred by older women and by those who felt that their risk of developing breast cancer was high. These women felt that lifetime risk, because it was of greater magnitude, would be more persuasive in encouraging them to undergo screening. However, subjects also raised concerns that individual risk profiles may change over time, and the importance of competing risks that arise with aging. Some subjects seemed to discount years of life at an older age, as conveyed in the following quotation:

> I think with lifetime too, you think . . . I'll get it, I'll be 80, you have 79 good years, it will be the last year . . . who cares?

USING GRAPHICS TO CONVEY UNCERTAINTY

We used a graph to convey the concept of uncertainty associated with risk estimates. Participants discussed their response to a line graph that portrayed an estimate of breast cancer mortality relative risk reduction for women 40 to 49 years old. In addition to the point estimate, the graph conveyed a confidence interval around the estimate (Figure 6). Themes that emerged from this discussion included the following. Women in the less-educated groups associated the presentation of a range around the estimate as "vague" or "wishy-washy," and for some, the graphic information decreased their trust of the risk estimates being conveyed. Women in the more-educated groups conveyed a theme of acceptance of uncertainty in scientific data. The dominant, although not uniform, response in the more-educated groups was that the confidence interval should be presented to the patients so that all the information can be used in making a decision.

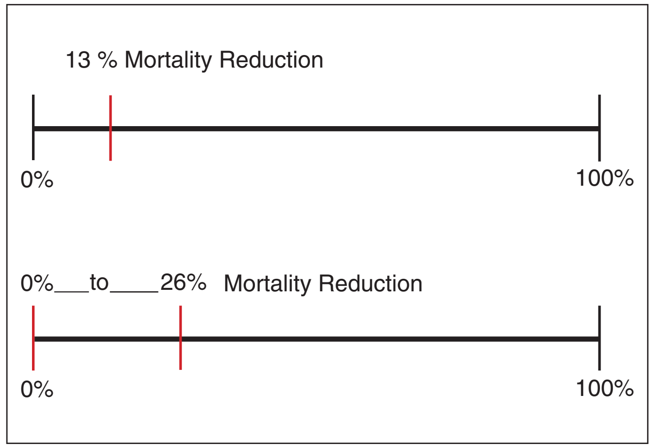

Figure 6. (Top) Estimate for the relative risk reduction of breast cancer mortality associated with the use of mammography screening in women 40 to 49 years old. (Bottom) Confidence intervals around the mortality risk reduction estimate.

Discussion

Our study provides new insights into constructs patients use when interpreting numeric risk information presented with frequency and probability formats. Frequency formats were noted to have attributes of ease of interpretation, simplicity, and the ability to provide a human contextual quality in the graphics. Probability formats were noted to have attributes of an association with personal risk estimation and a mathematical quality. Potential biases associated with these formats were also suggested by the data.

Frequency and probability formats are both based on the central tenant of probability theory, that is, that the likelihood of an event can be assigned a value between 0 and 1. A frequency format presents the chance of occurrence as a proportion of discrete cases over those at risk for an occurrence. A probability format typically presents the chance of occurrence as a percentage. Probability judgment problems are thought to be solved by people using a combination of quantitative reasoning and intuitive estimation.[43] The optimal format to assist human judgments is not clear. Gigerenzer argued that in judgments using Bayesian reasoning, absolute frequency formats are more intuitive and easier to use than percentages.[44-46] Rates (defined as disease per unit of population, commonly 100 or 1000) have performed better than proportions (defined as 1 in the numerator with shifting denominators) in both gross comparison and risk assessment tasks.[47,48] In our study, subjects could easily visualize 10 or 100 persons and had an intuitive understanding of the magnitude of risk conveyed with a frequency format using these denominators. Further studies must evaluate whether these attributes lead to an increased ability to compare risks or, ultimately, changes in health behavior based on risk information.

Graphic aids for frequency or probability formats are a 2nd dimension of risk communication. In a study of performance of graphic formats, Feldman-Stewart and others[29] found that for simple comparative tasks, vertical bars outperformed systematic (consecutively highlighted) ovals and randomly highlighted ovals. However, for more complex tasks involving estimation of the difference between 2 risks or the magnitude of a single risk, the systematic ovals outperformed vertical bars. Our focus groups were primarily interested in the use of formats to convey single risk estimates, for which highlighted human figures had great salience. However, when asked to respond to the use of vertical bar graphs to present comparative risks, subjects identified the attributes of simplicity and richness of information in that graphic format. Our study suggests a reason that the random ovals performed poorly in risk estimation tasks[29]: Participants uniformly found it difficult to cognitively process the magnitude of risk when presented with randomly highlighted human figures. In the design of graphics for decision aids, one may have to balance competing attributes of various graphic formats. The optimal format for presenting a single risk estimate may differ from that for comparing the relative magnitude of multiple estimates.

We report a new finding with regard to graphic formats and the magnitude of subjective risk perceptions. Our study suggests potential biases in perceptions of risk magnitude based on the graphic format used (highlighted human figures vs. bar graphs) and the size of the denominator when using a graphic of highlighted human figures. Among some participants, identical numeric risks were perceived as less when presented with bar graphs compared to highlighted human figures. Focus group discussions revealed that the reason for this bias might be the increased salience and personal quality of the data when presented in the form of a human figure. Subjects also appeared to round up the 0.9/10 numeric to 1/10. The human figure in which 90% of the area was highlighted was often perceived as being 100% highlighted (Figure 1).

The dominant opinion in our focus groups was a perception of lesser risk when identical probabilities were displayed with highlighted human figures with larger versus smaller denominators. Subjects appeared to focus on the increased number of figures in the denominator (indicating no disease) rather than the increased number of highlighted figures in the numerator (indicating disease). This finding is consistent with prior work demonstrating a response range effect on subjective risk assessments. Yamagishi[49,50] reported that risk estimates were greater when ascertained on an X out of 100 scale compared to an X out of 10,000 scale. These potential biases in risk magnitude estimation associated with graphic format need further study in a larger, more representative population of patients.

Consistent with prior studies, subjects found it easier to work with denominators of 10 or 100 compared to larger denominators.[51] However, some questioned the validity of risk estimates when human figure graphics with a denominator as low as 10 were used. This finding is consistent with the empirical law of large numbers that states that people have a general intuition that larger samples lead to more accurate estimates of population means.[52]

We report a new finding with regard to the time frame used in risk communication. Preferences for time frame over which to present risk information appeared to depend on where a woman was in her lifecycle. Younger women preferred 10-year risk estimates, and older women preferred lifetime estimates. Prior studies report that people do not accurately estimate lifetime risks when presented with shorter term risks.[53] Further work is needed to define the optimal time frame in which cumulative risk estimates should be conveyed in the context of medical decision making, and to determine whether the time frame should be tailored to patient characteristics such as age.

The more educated women in our focus groups (with at least a 4-year college degree) were quite sophisticated with regard to concepts of risk. These women were concerned with the source and validity of data presented and questioning of their relevance to their personal situation. Participants in the more-educated groups appeared comfortable with concepts of uncertainty associated with risk estimates. Uncertainty in science is a concept that has varying amounts of acceptance.[54] Less-educated groups were somewhat unsure about the meaning of numeric frequency and probability terms and generally desired the information to be conveyed in a simpler format. Despite these differences, many of the themes highlighted above were common to less- and more-educated groups.

These findings must be interpreted within the limitations of the study design. Qualitative methods are meant to be inductive rather than deductive. The sampling for focus groups is not random, and findings should not be generalized to a broader population. Rather, findings from focus groups can be used to generate hypotheses that can be developed and further tested using quantitative methods. Although inductive in nature, the methods used in focus groups including segmented sampling, use of a moderator, matching the method to the phenomenon of interest, and formal data analysis lend strength to the validity of the findings.[36] Although our study included some of these validity checks, other methods were not included. Within the spectrum of qualitative research, focus groups have the hypothesized advantage of enriched data due to group interaction. However, this hypothesis was not supported in a randomized controlled trial comparing the number of ideas arising from focus groups to the number arising from individual structured interviews.[55] In addition, the means of recording the data with a tape recorder and videotape may inhibit participants' full expression of ideas, particularly among certain cultural groups.[56,57] Despite these limitations, focus group methods are increasingly used in health services research to define initial constructs of health beliefs, attitudes, and behavior. Findings can be compared, when appropriate, to data gathered from other qualitative methods (such as individual interviews or direct observations) or further studied using quantitative methods in a broader spectrum of subjects.

In conclusion, our study suggests specific attributes associated with formats commonly used in risk communication. The personal relevance attributed to the data and perceptions of risk magnitude vary with format and time frame used to present risk information. Health care researchers and clinicians have an ethical obligation to use these findings appropriately.[58] Risk formats should be chosen to optimize patient understanding and ability to use the information effectively, rather than for the purpose of persuasion. Qualitative methods provide a valuable tool for exploring how patients interpret and assign meaning to probabilistic information.

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