COMMUNICATIONS TO REDUCE RISK UNDERESTIMATION AND OVERESTIMATION

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Rutgers, The State University of New Jersey

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U.S. Environmental Protection Agency
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EXECUTIVE SUMMARY

There is considerable agreement about the difficulty of conveying information to the public about the magnitude of risks. As many discouraged policy-makers have noted, citizens often ignore information designed to alert them to significant risks; yet these same citizens may insist on remedial action for other risks that are too small to merit the attention they receive. Even when people obtain their own tests, as with home measurements for airborne radon or lead in drinking water, there may be only a weak relationship between their test results (a measure of risk magnitude) and their responses.

A substantial research literature has identified many of the factors other than risk magnitude that seem to explain why some hazards provoke a far greater response than others. But much less research has attempted to determine how best to explain risk magnitude. Without making any judgment about which factors "should" influence risk response, it seems unarguably desirable that people understand risk magnitude information so that, at least when the other factors are held constant, there is a strong correlation between the magnitude of the risk and the magnitude of the response.

Research in the first two budget periods of this cooperative agreement assigned subjects a hypothetical test result for radon or asbestos, provided a constant fact sheet about the hazard, and explained their risk magnitude using various techniques. Subjects were then asked questions about their threat, mitigation intentions, and related perceptions. A significant risk magnitude effect was found; that is, subjects responded with higher risk perception when the risk magnitude was higher. Three specific components were found to improve the risk magnitude explanations: (1) A recommended action standard; (2) Explicit advice on what to do at various concentration levels; and (3) A risk ladder showing a range of possible test results and the risk magnitude associated with each (with ladders designed so that subjects' test results appeared high on the ladder if the goal is to increase risk perception, and low on the ladder if the goal is to decrease risk perception). Risk comparisons were found to be helpful in some ways, but they did not significantly affect threat perceptions or action intentions.[1]

The research reported here expanded this previous research in two directions: It tested an approach in which comparisons to normal background levels are provided instead of illness likelihood information, and it examined communication in two situations in which the risk itself was quite low, one of them a high-outrage risk controversy.

Three hypothetical news stories were used: a low-outrage, high-risk story ("radon"), a high-outrage, low-risk story ("nuclear waste"), and a low-outrage, low-risk story ("radiation"). For each of the first two stories, there were four treatments: (1) A "base risk" treatment in which subjects were given their hypothetical test result and an estimate of the lifetime cancer risk associated with that result, in terms of deaths per 1,000 people; (2) An "alternate risk" treatment in which subjects were provided the same information, but with a test result and risk estimate 10× [i.e. ten "times"] higher (for the low-outrage, high-risk radon story) or 10× lower (for the high-outrage, low-risk nuclear waste story); (3) A "compare to normal" treatment, in which subjects were given the same test result as in the "base risk" treatment, but with a comparison to normal background levels provided instead of the risk magnitude information; and (4) A "base risk + chart" treatment, in which subjects received the risk information augmented with a risk ladder, risk comparisons, and a recommended action level. For the radiation story, only the "base risk" and "base risk + chart" treatments were used, yielding a total of ten conditions in the study. The hope was that some of these treatments would increase responses to high risk levels and decrease responses to low risk levels.

Subjects were 1,402 homeowners in Irmo, South Carolina and Cary, North Carolina. Each received a four-page, 8½"-by-11" pamphlet. The first page of the pamphlet was a cover letter stating that the task was to "tell us how you think you would feel in this situation and what you think you would do." Page two and the top of page three contained the particular news story subjects were asked to read. The story was followed by various types of information designed to help subjects interpret their radiation test result. The feedback questionnaire included four

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[1]For the complete reports of these findings, see (1) Neil D. Weinstein, Peter M. Sandman, and Nancy E. Roberts, *Communicating Effectively about Risk Magnitudes* (Washington, DC: Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, 1989, Document EPA-230-08-89-064); and Neil D. Weinstein, Peter M. Sandman, and Paul Miller, *Communicating Effectively about Risk Magnitudes, Phase 2* (Washington, DC: Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, 1991, Document EPA-230-09-91-003). Both are also available from the Center for Environmental Communication, Cook College, Rutgers University, New Brunswick, NJ 08903.

questions that were later combined into an index of perceived threat, and four questions that were later combined into an index of action intentions. Other questions included checks on the understandability of the news story and the risk information, checks on the outrage manipulation (anger, distrust), and demographic items.

The Effects of Comparisons to Normal Background. The most surprising finding was the powerful impact of comparisons to normal background on threat perceptions and action intentions. Compared to the "base risk" condition, information that their radiation exposure was 20× higher than normal background increased subjects' perceived threat for the low-outrage, high-risk radon scenario, and information that their radiation exposure was 200× lower than normal background decreased both perceived threat and action intentions for the high-outrage, low-risk nuclear waste scenario.

The Effects of the Risk Chart. Similar effects were achieved by supplementing the risk numbers in the "base risk" condition with a chart that included a risk ladder, risk comparisons, and a recommended action standard. The chart increased perceived threat in the high-risk radon situation and decreased perceived threat in both low-risk situations (the high-outrage nuclear waste situation and the low-outrage radiation situation). The effects of the chart were roughly equal to the effects of comparisons to normal background – they were as great as a 10× increase in actual risk for radon, and were greater than a 10× decrease in actual risk for nuclear waste. Similarly, compared to the "base risk" condition, the chart decreased action intentions for the nuclear waste and radiation scenarios, though the effect on action intentions for radon was not quite significant.

The Effects of Risk Magnitude. The research in the second budget period demonstrated an effect of risk magnitude on risk perception. This finding was replicated in the research reported here. Comparing responses in the low-outrage, low-risk radiation situation with responses in the low-outrage, high-risk radon situation gives on a measure of risk magnitude effects. For both the "base risk" treatment and the "base risk + chart" treatment (the only two used with both low-outrage stories), subjects experienced higher threat perceptions and action intentions when the risk was high (40 in 1,000) than when the risk was low (1 in 100,000). The difference between the two was greater for the "base risk + chart" treatment than for the "base risk" treatment, demonstrating that the chart helped subjects respond appropriately to the level of risk. But even with the bare data provided in the "base risk" treatment, a 40-in-1,000 risk yielded higher threat perceptions and action intentions than a 1-in-100,000 risk. The "alternate risk" treatment provided a more sensitive test of the same question. For the low-outrage, high-risk radon situation, a 10× increase in risk from 40-in-1,000 to 400-in-1,000 yielded a significant increase in threat perceptions and action intentions. But for the high-outrage, low-risk nuclear waste situation, a 10× decrease in risk from 1-in-100,000 to 1-in-1,000,000 did not significantly affect threat perceptions or action intentions.

Outrage Effects and Outrage Reduction. Not surprisingly, outrage substantially affected threat perceptions and action intentions. Subjects in the high-outrage, low-risk nuclear waste situation reported much higher perceived threat and higher action intentions than subjects in the low-outrage, low-risk radiation situation, although the actual risk was identical. More striking, for subjects with the "base risk" treatment, intentions to take action were just as strong for the high-outrage, low-risk (1 in 100,000) nuclear waste situation as for the low-outrage, high-risk (40 in 1,000) radon situation. In addition, anger was highly correlated with threat perception and action intentions, as was distrust of the Department of Environmental Protection spokesman for subjects in the high-outrage situations. Most encouraging is the apparent ability of some kinds of risk information to reduce threat perception and action intentions for very low risk levels even in the presence of high outrage. Both comparisons to normal background and the risk chart had this effect for subjects exposed to the nuclear waste scenario. Many practitioners have suggested that when people are outraged, explanations of the risk data are unlikely to prove fruitful. Outrage certainly increased threat perceptions and action intentions in the study reported here, but outrage did not diminish the ability of comparisons to background and risk charts to reduce threat perceptions and action intentions.

The risk communication strategies that were helpful in the present research need to be tested in real-world situations. When citizens' own lives are affected, they may well prove less interested in risk magnitude information and more sensitive to outrage factors.

INTRODUCTION

There is considerable agreement about the difficulty of conveying information to the public about the magnitude of risks. As many discouraged policymakers have noted, citizens often ignore information designed to alert them to significant risks; yet these same citizens may insist on remedial action for other risks that are too small to merit the attention they receive. Even when people obtain their own tests, as with home measurements for airborne radon or lead in drinking water, there may be only a weak relationship between their test results (a measure of risk magnitude) and their responses. Furthermore, the response to risk numbers for one hazard is often very different from the response to similar risk numbers for a different hazard. Some hazards seem to provoke a conservative response from the public, while others – even given test results that indicate a comparable risk – elicit much less concern.

A substantial research literature has identified many of the factors other than risk magnitude that seem to explain why some hazards provoke a far greater response than others. But much less research has attempted to determine how best to explain risk magnitude. Without making any judgment about which factors "should" influence risk response, it seems unarguably desirable that people understand risk magnitude information so that, at least when the other factors are held constant, there is a strong correlation between the magnitude of the risk and the magnitude of the response. Aside from the research whose third stage is reported here, there have been relatively few empirical studies to support claims that one approach works better than another.

Research in the First Budget Period[2]

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[2]The complete report of these findings is found in Neil D. Weinstein, Peter M. Sandman, and Nancy E. Roberts, *Communicating Effectively about Risk Magnitudes* (Washington, DC: Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, 1989, Document EPA-230-08-89-064). It is also available from the Center for Environmental Communication, Cook College, Rutgers University, New Brunswick, NJ 08903

The research conducted in the first budget period examined a variety of promising risk presentation formats and tested their success in communicating about two different hazards, geological radon and asbestos. Seven formats were evaluated, with varying combinations of the following elements:

Risk Probabilities	Information about expected lifetime mortality at various levels of exposure.
Risk Comparisons	Comparisons to smoking risks.
Histogram	Mortality rates displayed in histogram form.
Standard	Information about the recommended action level.
Advice	Detailed action advice and verbal labels for various exposure levels.

Subjects were New Jersey homeowners who had not tested their homes for the hazard in question (either radon or asbestos). Each subject was asked to assume that he or she had tested and that we were delivering the test result. Each subject also received a four-page brochure discussing the hazard. The first three pages were constant across conditions; the fourth page consisted of the experimental manipulation. Subjects then responded to an evaluation questionnaire, giving judgments of "their" risk, "their" level of concern and fear, "their" likelihood of mitigating, "their" illness probability, the helpfulness of the brochure, and other issues. Four readings were used for each hazard, one well below the recommended action level, one slightly below the level, one slightly above the level, and one well above the level.

Among the major findings were the following:

1. **The value of the research design.** The experimental design created for the first budget period proved to be an efficient, cost-effective, and flexible way to investigate format effects on risk perception and risk response. It avoided the ethical problems of testing experimental formats in the context of actual risk situations, yet maintained an acceptable degree of realism.

2. **The value of an action standard.** The formats with a standard did appreciably better than those without a standard at helping people distinguish between high and low levels of the same hazard. The addition of risk magnitude information or action advice did not lead to a further differentiation between high and low levels.

3. **The value of advice.** In this study people were more risk-averse than the action recommendations; they often said they would mitigate at levels below the guideline. Those receiving action advice were most likely to accept the recommendations (that is, least likely to "overreact" vis-à-vis the standard).

4. **The value of smoking comparisons.** The effects of smoking comparisons were inconsistent, varying with the outcome variable. They improved subjects' ratings of the brochures and raised the maximum level subjects would regard as acceptable, but they did not influence perceptions of risk seriousness or intentions to mitigate.

5. **"Locational" responses.** Perhaps the most important finding of the first budget period was the great similarity in subjects' responses to radon and asbestos, despite the fact that the lowest radon reading was 25 times as risky as the lowest asbestos reading, and the highest radon reading was 25 times as risky as the highest asbestos reading. Though several formats proved useful in producing substantial increases in response *across the four levels for each hazard*, no format was efficacious in producing appropriate differences in response *between the two hazards*. It was hypothesized that the data might be explained by a "locational" (i.e. placement) effect. For both radon and asbestos, high concentrations were located high on the full-page "risk ladder," and low levels were low on the ladder. If risk perceptions were shaped by location, people would view high levels as riskier than low levels (within each hazard), but would not recognize the difference in risk between the two hazards. In other words, where risk was proportional to location (within hazards), several formats worked well; where risk was not proportional to location (between hazards), no format worked well. What looked like a response to different risk magnitudes might have been chiefly a response to location.

Research in the Second Budget Period[3]

Research in the second budget period consisted of three experiments designed to address questions raised by the results of the first budget period. The general research approach was unchanged. Subjects were asked to assume a particular hypothetical home test result for either radon or asbestos in their own

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[3]The complete report of these findings is found in Neil D. Weinstein, Peter M. Sandman, and Paul Miller, *Communicating Effectively about Risk Magnitudes, Phase 2* (Washington, DC: Office of Policy, Planning, and Evaluation, U.S. Environmental Protection Agency, 1991, Document EPA-230-09-91-003). It is also available from the Center for Environmental Communication, Cook College, Rutgers University, New Brunswick, NJ 08903.

home, to read a brochure about the radon or asbestos hazard with that test result in mind, and then to complete a questionnaire on their assessment of the risk represented by their assigned test result. Both the assigned test result and the format of the interpretive brochure were systematically varied, and the results were analyzed in terms of the efficacy of different format characteristics in communicating different levels of risk.

The first experiment was a direct extension of the first budget period finding that the standard-only format yielded highly risk-averse responses. It tested the hypothesis that this might be attributable to the absence of the locational cues of a risk ladder in the standard-only condition. The experiment compared the effects of the standard-only format and a new standard+ladder format for four hypothetical asbestos levels. The hypothesis that the addition of a risk ladder would significantly reduce the perceived risk was confirmed, though the effect was very small.

The second experiment compared the effects on risk perception of risk magnitude (actual differences in the probability of harm), location on the risk ladder, and test numbers (for example, whether responses would differ if asbestos were reported as 10 fibers per liter rather than as 1 fiber per deciliter, though the difference represents merely a change in unit). These three factors, confounded in the first budget period research, were manipulated separately in the second experiment. Subjects were randomly assigned to one of four information format conditions (base, displaced on the risk ladder, high test numbers, and high risk). The results showed that both risk magnitude (probability of illness expressed in cases of lung cancer per 1000 people exposed plus smoking comparisons) and location on the risk ladder affected risk perceptions. When risk information was provided and the risk itself was constant, changing the test numbers by altering the units had no effect according to any criterion.

The third experiment explored two new questions. The first question was the effect of simultaneously presenting both asbestos and radon risk information (as opposed to presenting the identical information on one hazard alone) in the hope that this joint presentation might help people recognize the difference in risk between the two hazards. The second new question was the effect of differences in the identity of the hazard itself, independent of location, test number, or risk level. In addition, the third experiment sought to replicate the locational effect and the risk effect found in the second experiment. A total of six presentation formats were used. The data showed no evidence of any difference between simultaneous and separate presentations of information about the two hazards. Nor, surprisingly, was there any evidence of a hazard identity effect, at least insofar as these two hazards were concerned; when the size of the risk and the location on the page were held constant, subjects' risk perceptions for radon were not significantly different from their risk perceptions for asbestos. As in the second experiment, significant risk magnitude and locational effects were found; a half-page locational displacement had about the same impact on risk perception as a 10-fold difference in the magnitude of the risk.

Three Unanswered Questions

What did we learn from the first two budget periods to guide us in trying to explain risk magnitudes? We learned that the task is not impossible. When risk magnitude data are presented, high risks do generate higher perceived threat and greater intentions to take action than lower risks. We also identified three factors other than risk magnitude data that significantly affect risk perception: action standards, explicit advice, and location on a risk ladder. Finally, we learned that all of these effects are relatively small; studying them reliably requires sizable samples of study participants and sensitive response measures.

Three unanswered questions were identified for the focus of the third budget period, as follows:

The Role of Graphic Representations

An approach not explored in the first two budget periods was the use of graphic representations of probability or concentration data. The first EPA *Citizen's Guide to Radon* made considerable and controversial use of a matrix of faces and crosses to show risk probabilities. A later EPA report, *Hazardous Substances in our Environment: A Citizen's Guide to Understanding Health Risks and Reducing Exposure* (EPA 230-09-90-081), used a similar matrix. One published report (Kaplan, Hammel, & Schimmel, 1985) suggests that a similar graphic approach may help to lower anxiety about low-probability risks. These researchers used a simple matrix of dots to convey the denominator of an odds statement (1-in-1,000 or 1-in-10,000 or 1-in-100,000). The college student subjects were less worried about the side-effects of a hypothetical vaccine if the odds were accompanied by a matrix of dots than if the numbers were presented by themselves. This intriguing result required verification and expansion to more serious risks: Would the graphic approach lower concern even when the risk was substantial, or in this case would it raise concern instead?

The Relative Impact of Different Treatments

Based on the work of the first two budget periods, a risk explanation aiming at maximum impact would include: (1) risk probability information for the subject's assigned test result; (2) a risk ladder with risk probability information for different concentration levels, designed so as to put the subject's test result high or low on the ladder depending on whether the goal is to raise or diminish risk perception; (3) an action guideline, perhaps with explicit advice on what to do at various levels; and (4) comparisons to more familiar risks.[4]

A question for the third budget period, then, was the relative impact of this "best shot" risk information package. Two comparison treatments were obvious candidates. One would be a baseline treatment giving subjects no risk information whatever, only the basic concentration information that comes from a test result: so many parts per million, picoCuries per liter, etc. The other would be a simple presentation of the quantitative risk likelihood at the subject's assigned test result, without the risk ladder, action guideline, or comparisons.

Augmenting versus Diminishing Perceived Risk

Conceptually, the issue of explaining risk magnitudes probably cannot be meaningfully investigated without regard to direction, because – as the first budget period research suggested – different strategies may be required for helping people see that a small risk is small than for helping people see that a large risk is large. (Advice, for example, was much better at the former than the latter.)

Moreover, the policy implications of the two types of risk communication are quite different. In recent years the Environmental Protection Agency has devoted considerable effort to exploring the discrepancies between expert and public assessments of risk and to developing policies that take cognizance of these different assessments (USEPA, 1987; USEPA, 1990). The need to become more skilled at explaining serious risks is grounded in public health and similar concerns; lives are at stake when an agency tries to warn people about serious risks. When people persist in worrying disproportionately about minuscule risks, in contrast, the costs range from unnecessary anxiety to misused environmental protection dollars, from public policy gridlock to reduced agency credibility.

The research of the first two budget periods focused on two hazards, radon and asbestos in residences. Although radon is the more serious of the two (at the levels typically encountered and at the levels used in the research), both pose serious risks. Residential radon and residential asbestos are not identical hazards, of course. But on the variables that best predict whether a hazard will provoke

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[4]The research in the first budget period was inconclusive on the effectiveness of risk comparisons, but did find that people believe risk explanations are clearer and more helpful when comparisons are given. A study focusing explicitly on risk comparisons was conducted in Part One of the third budget period, and has already been reported (Weinstein and Sandman, 1991). It found virtually no differences among radon risk explanations with various sorts of risk comparisons or no risk comparisons at all .Nonetheless, the earlier decision to include risk comparisons in this study was not reversed

underreaction or overreaction from the public – dread, control, familiarity, trust, fairness, etc. – they are similar, in that both tend toward underreaction. (As noted earlier, significant risk perception differences between the two hazards were not found when risk level and location on the risk ladder were held constant.) The research of the first two budget periods, in other words, shed considerable light on how to alert people to serious risks but much less light on how to reassure people about negligible risks.

The distinction is especially important for negligible risks that are serious sources of public concern. It is often argued that the public responds less to the seriousness of a risk (or its knowledge about seriousness as obtained from agency communications, the media, or other sources) than to such factors as trust, control, fairness, and courtesy. Sandman (1987, 1991, 1993), Hance *et al.* (1988, 1990), and Sandman *et al.* (1987) have proposed the labels "hazard" and "outrage" to refer, respectively, to the technical and the nontechnical aspects of risk. Using different vocabulary, many others have also noted and studied the importance of these nontechnical aspects of risk perception, among them Kasperson (1986), Krimsky and Plough (1988), Covello *et al.* (1988), Covello and Allen (1988), and Slovic (1987).

In Sandman's terminology, "hazard" is the product of risk magnitude and probability, while "outrage" is a function of whether people feel the authorities can be trusted, whether control over risk management is shared with affected communities, etc. Supporters of this distinction argue that hazard and outrage are both components of risk deserving attention, and that laypeople have had as little success communicating what they consider significant about risks to the experts as the experts have had communicating to the public. No matter how serious the risk is (in hazard terms), and no matter how effectively it is explained, this view maintains that the degree of *outrage* is likely to determine much of the public's response to the risk.

Three experimental studies of outrage (Sandman *et al.*, 1993), employing hypothetical news stories, found higher perceived risk when the manipulated outrage was high than when outrage was low. For example, risk perception was higher when the agency responsible for a spill cleanup was reported to be unresponsive to citizen concerns and neighbors were reported to be outraged than when the agency was responsive and neighbors were grateful. The outrage manipulation had more impact on risk perception than a 10,000-fold difference in risk magnitude; the amount of technical information in the news stories had no impact on risk perception at all.

In the language of "hazard" versus "outrage," then, the research of the first two budget periods focused on risks that were moderate to high in hazard and low in outrage. An important unanswered question was how effective the approaches developed in the first two budget period would prove when applied to a risk that is low in hazard and high in outrage.[5]

In this context, it is worth emphasizing that these approaches are all ways of *explaining* risk magnitude more effectively. That is, risk data, risk comparisons, graphic displays, advice, standards, and risk ladders are all ways to help people understand the magnitude of their risk. A more controversial class of risk communication strategies involves efforts to influence risk response emotionally or behaviorally rather than through improved comprehension: dramatic fear appeals, social pressure, rewards for compliance, etc. Considerable research demonstrates that these non-cognitive approaches can be very effective – but many scientists object to them, believing that risk is a technical problem that should be explained in technical (though understandable and perhaps necessarily simplified) terms. The question, then, is how much can risk response be shaped simply by presenting the data effectively. The research carried out in the first two budget periods constitutes a sustained effort to answer this question in the context of a serious risk that people are inclined to underestimate.[6] The research carried out in the third budget period expands that inquiry to inconsequential risks that people are inclined to overestimate, in large measure because they are outraged.

The Original Proposed Design

To answer these three questions, the third budget period proposed an 8-condition research design.

Two hypothetical risk situations were proposed: a low-outrage, high-risk hazard to which the public typically underreacts and a high-outrage, low-risk hazard to which the public typically overreacts. We tentatively selected radon once again for the former, and low-level radioactive waste facilities for the latter.[7] Both are issues with important current policy implications. In both cases,

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[5]This report will use Sandman's term "outrage" to cover the nontechnical aspects of risk. However, the technical aspects (in this case, the quantitative likelihood of illness) will be referred to by the conventional terms "risk" and "risk magnitude," rather than Sandman's "hazard." "Hazard" will be used instead in the conventional way, to describe the substance or situation that poses a risk. Thus, what Sandman would call a "high-outrage, low-hazard risk," we will call a "high-outrage, low-risk hazard."

[6]Research at Carnegie Mellon University has also focused on this issue. See for example Ibrekk & Morgan, 1987.

[7]The high-outrage, low-risk scenario was later changed from a low-level radioactive waste site in the neighborhood to the illegal use of mildly radioactive sand from a nuclear power plant in the manufacture of the cement from which home foundations were constructed. Thus, both the high-

ongoing risk communication programs at EPA and other agencies could make immediate use of our results. In addition, since both are radiation hazards, we expected to be able to produce risk explanations that were similar in terms of the possible disease outcome, the units in which exposure is measured, etc. At the same time, there is wide agreement that the task of explaining radon risk magnitudes is explaining that they are substantial, while the task of explaining low-level radioactive waste facility risk magnitudes is explaining that they are minimal. (There are of course other policy issues and other legitimate sources of controversy for both hazards.)

For each of these two hazards, we proposed four treatments, as follows: (1) **Baseline.** The baseline treatment would give subjects no risk information at all, only the basic concentration information that comes from a test result: so many parts per million, picoCuries per liter, or whatever. (2) **Base risk.** The second treatment would augment the concentration information with quantitative risk information — for example, "so many parts per million of ________ is expected to cause X additional cases of cancer per 1,000 people exposed." (3) **Graphic display.** The third treatment would assess the value of adding a single factor to the quantitative concentration and risk information already present in the second treatment. In this case the added factor would be the use of a matrix of dots to make more concrete, more visible, the size of the risk being presented. (4) **Base risk + chart.** The previous stages of this research shed light on the impact on risk perception of location on a risk ladder, action standards with advice, and risk comparisons. The "best shot" treatment would add a chart incorporating these factors to the quantitative concentration and risk information in the second treatment.

The proposed design entailed only one concentration/risk condition for each hazard — a very sizable radon risk and a very tiny nuclear waste risk. In most other ways, the proposed design was identical to that of the first two budget periods. Subjects were to be recruited by telephone. Those who agreed to participate would be sent a hypothetical information brochure[8] explaining the radon or nuclear waste problem in their neighborhood, and a hypothetical test result for their particular home. All subjects would receive the same information brochure about either radon or nuclear waste, plus a final page with one of the treatments discussed above. Finally, subjects would be asked to complete a response questionnaire. The research in the first two budget periods showed that the greater sensitivity of a multi-question response scale is needed to demonstrate

outrage scenario and the low-outrage scenario featured an individual-level risk emanating from the subject's (hypothetical) basement.

[8]This was later changed to a hypothetical news story, making it easier to manipulate trust and outrage while preserving the credibility of the source of the concentration test result.

statistical significance for the sorts of effects studied. We therefore proposed that the four-question threat perception index developed earlier be used once again, and that a new multi-question index of action intentions be developed to replace the single-item measure of this variable used previously.

In summary, there were two series of research questions to be investigated during the third budget period, as follows:

(1) When subjects are presented with a serious radon risk that they are inclined to underestimate, how effective is each of the following in convincing them to see the risk as serious and intend to take action: (a) concentration data alone; (b) concentration and risk data; (c) concentration and risk data accompanied by graphic display; (d) concentration and risk data accompanied by standards with advice, risk comparisons, and locational cues in risk ladders, all used in the way that previous research showed was most likely to lead people to consider the risk more serious.

(2) When subjects are presented with an extremely small risk from nuclear waste that they are inclined to overestimate, how effective is each of the following in convincing them to see the risk as insignificant and not intend to take any action: (a) concentration data alone; (b) concentration and risk data; (c) concentration and risk data accompanied by graphic display; (d) concentration and risk data accompanied by standards with advice, risk comparisons, and locational cues in risk ladders, all used in the way that previous research showed was most likely to lead people to consider the risk less serious.

Changes in the Design

The design as carried out differed from the design originally proposed and described above in four important ways.

Separation of the Graphic Display Study

In the absence of prior research (except for the single study by Kaplan *et al.*, 1985), it was difficult to determine what particular form the matrix of dots should take in the graphic display portion of the study. To help answer this question, two preliminary experiments were conducted, with university students as subjects. The first experiment used two different hypothetical health risk decision problems. It compared responses to three risk probabilities (1-in-50, 200-in-10,000, and 1-in-10,000) and three formats (no graphic display, a matrix of dots to represent the denominator of the probability fraction, and a matrix of dots and X's to represent the denominator and numerator, respectively). Because the first experiment failed to find any effects of graphic display, a second experiment was conducted to more precisely replicate the original Kaplan *et al.* design.

In neither experiment were threat perceptions or action intentions significantly different with any visual display than with the numbers only. Because of the large samples used, the failure to detect an effect for graphic display cannot be attributed to inadequate statistical power in the experimental design. Of course visual displays other than those examined in these two experiments may eventually prove to be quite helpful. And even the visual displays studied may conceivably have some impact for risk levels greater or smaller than the range examined (1-in-50 to 1-in-10,000), or for audiences other than university students.

Nevertheless, these two experiments certainly did not support the idea that a visual display of dots helps people appreciate the magnitude of a risk. We therefore decided not to include a "graphic display" treatment in the experiment for the third budget period. A report of the two visual display experiments is incorporated into this report as Appendix A.

Addition of an Alternate Risk Level

One of the strengths of the research design in the second budget period was the use of two risk levels to establish a risk magnitude effect on threat perceptions and action intentions. The size of this effect could then be directly compared with the size of the other experimental effects – establishing, for example, that the difference between a location one-quarter of the way up the risk ladder and one three-quarters of the way up the ladder had roughly the same effect on perceived threat as a 10-fold difference in actual risk.

As originally proposed, the research in the third budget period would lack this strength, since only one risk level would be studied for each scenario. We therefore decided to add an "alternate risk" treatment, identical in form to the "base risk" treatment (that is, with information provided about the level of risk at the subject's assigned concentration but with no risk ladder, risk comparisons, or standard), but with a 10-fold difference in the risk magnitude itself.

For the radon scenario, a base risk of 40 additional lung cancer deaths in 1,000 was established. The alternate risk condition was therefore set at 400 in 1,000 – ten times greater. Thus, the effectiveness of the various treatments in convincing subjects that a 40-in-1,000 risk is worth taking seriously could be compared to the increased threat perceptions and action intentions when the risk was hiked to 400-in-1,000.

For the nuclear waste scenario, a base risk of 1 additional lung cancer death in 100,000 was established. Since the goal of risk communication in this case is presumably to convince people that the risk is a very minor threat and no action is justified, the alternate risk condition was set ten times smaller than the base risk, or 1-in-1,000,000.

Addition of a Low-Outrage, Low-Risk Scenario

Both of the hazards used in the first two budget periods, radon and asbestos, are moderate to high in risk and low in outrage (at least when found in one's own home). One of the main goals of the research in the third budget period was to find out whether the approaches identified as helpful in explaining the magnitude of such a risk would work as well when the risk was low and the outrage high – for example, with nuclear waste.

However, this contrast of a low-outrage, high-risk hazard with a high-outrage, low-risk hazard is really two contrasts: whether the risk is high or low, and whether the outrage is high or low. That is, one question is how to convince people that their risk is indeed low – whether the approaches that help people understand a high risk magnitude will also help them understand a low risk magnitude. A second question, conceptually quite different, is what to do when outrage is high. An approach that may work in both a low-outrage, high-risk situation and a low-outrage, low-risk situation – that is, an approach that helps explain both kinds of risk – may nonetheless prove ineffective when high outrage clouds the issue. Similarly, a study that found that a particular approach works for the low-outrage, high-risk situation but does not work for the high-outrage, low-risk situation would leave unanswered the effectiveness of that approach when outrage and risk were both low.

To remedy this problem, we decided to add a low-outrage, low-risk scenario. (To maintain high sample sizes in each condition, only "base risk" and "base risk + chart" treatments were added for this scenario.) The fourth logically possible scenario, high outrage and high risk, probably does not require much research. It is not difficult to convince people to take a situation seriously when both outrage and risk are high.

Addition of Comparisons to Background

As originally conceptualized, the baseline condition in this research was to have provided no risk information at all. Subjects would simply be given a hypothetical test result, expressing their concentration without any explanation of the associated risk. This is by no means an unrealistic condition. Well water test results, SARA Title III data, and a wide range of other hazard communications come in the form of concentration information without risk information.

However, even though people often receive concentration information without risk information, and even though they presumably reach some intuitive sense of the riskiness of their exposure based on the information available to them, the hypothetical situation originally proposed for the baseline condition does lack verisimilitude. How could we ask subjects to answer a series of questions about the seriousness of the risk (and the clarity of the risk explanation), when they have simply been told that they have a reading of so many picoCuries per liter, and nothing more?

We therefore decided to add some information to the baseline condition — not information about risk magnitude, but something to provide at least minimal context and to make the task seem more realistic. The information added was information comparing the subject's test result to normal background exposures to radiation. Normal background levels of breathable radiation average roughly 0.4 picoCuries per liter of air. Accordingly, the "baseline" condition for radon included the information that the radon test result of 8 picoCuries per liter was 20× greater than normal background radiation; and the "baseline" condition for nuclear waste included the information that the nuclear waste test result of 0.002 picoCuries per liter was 200× less than normal background radiation.[9] The "base risk" condition did not include this information; it included information about the risk magnitude associated with the test result instead. The "base risk + chart" condition included comparisons to background among the other comparisons on the risk chart, but did not explicitly point out that the subject's assigned test result was 20× more or 200× less than normal background.

As will be seen in the results section, this information about comparisons to normal background turned out to be highly impactful, both in increasing the response to a high risk and in decreasing the response to a low one. As it turned out, then, the study has no real "baseline" treatment. Instead, there are four treatments: "base risk," with information provided about the risk at the subject's level only; "alternate risk," with the same information provided but a 10-fold greater or lesser level of risk; "compare to normal," with no risk information but instead information about the comparison to normal background; and "base risk + chart," our attempt to produce the maximum impact communication.

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[9]In reality it would not be technically possible to attribute a radiation level of 0.002 picoCuries per liter to nuclear waste, since normal background levels are much greater than this figure and vary significantly from house to house and from day to day.

METHOD

Experimental Conditions

Three hypothetical news stories were used: a low-outrage, high-risk story ("radon"), a high-outrage, low-risk story ("nuclear waste"), and a low-outrage, low-risk story ("radiation").

For each of the first two stories, four treatments were used: (1) A "base risk" treatment in which subjects were given their hypothetical test result and an estimate of the lifetime cancer risk associated with that result in terms of deaths per 1,000 people; (2) An "alternate risk" treatment in which subjects were provided the same information, but with a test result and risk estimate 10× higher (for the low-outrage, high-risk story) or 10× lower (for the high-outrage, low-risk story); (3) A "compare to normal" treatment, in which subjects were given the same test result as in the "base risk" condition, but with a comparison to normal background levels provided instead of the risk information; and (4) A "base risk + chart" treatment, in which subjects received the risk information augmented with a risk ladder, risk comparisons, and a recommended action level.

For the third story, only the "base risk" and "base risk + chart" treatments were used.

The radiation levels and explanatory information used in each of the ten experimental conditions are summarized in Table 1.

Sample

People who live in communities where radon problems are common may recognize 4 picoCuries per liter as the level at which action is recommended by the U.S. Environmental Protection Agency. Such knowledge could affect their response to the hypothetical radiation levels used in this experiment. To reduce this potential complication, the sample was recruited from two communities with quite low radon levels: Irmo, South Carolina and Cary, North Carolina. An additional reason for choosing these communities was their relatively high

Table 1
Experimental Conditions

Condition	Radiation level (pCi/L)	Interpretive information		
		Lung cancer probability	Comparison to normal background levels	Risk chart
Low Outrage, High Risk ("Radon")				
Base risk	8	40-in-1,000	--	--
Alternate risk	80	400-in-1,000	--	--
Compare to normal	8	--	20× greater than normal	--
Base risk + chart	8	40-in-1,000	--	YES
High Outrage, Low Risk ("Nuclear Waste")				
Base risk	.002	1-in-100,000	--	--
Alternate risk	.0002	1-in-1,000,000	--	--
Compare to normal	.002	--	200× less than normal	--
Base risk + chart	.002	1-in-100,000	--	YES
Low Outrage, Low Risk ("Radiation")				
Base risk	.002	1-in-100,000	--	--
Base risk + chart	.002	1-in-100,000	--	YES

Note: pCi/L = picoCuries of radiation per liter of air.

education level. People with more education would be more willing to agree to read the research materials and would be more likely to complete and return the feedback questionnaire.

Because several of the questionnaire items asked what decisions subjects would make about home remediation in the hypothetical situation presented, only owners of single-family dwellings – who might find it easier to imagine themselves in such a situation – were eligible. Within each such residence the male or female head of household was selected to participate, with the gender requested alternating from house to house.

Of those households where a telephone contact was made that met the selection requirements, 65.5% agreed to take part in the study. A total of 1803 individuals were recruited. With at least two reminder calls, 1402 (77.8%) returned completed questionnaires. This is a net response rate of 51.0%. The return rates were equal across conditions, removing any concern that differences among conditions might be caused by differential subject attrition. However, conclusions about differences among the treatments are limited to the homeowners who agreed to participate.

Overall, the sample was 53.3% female. The education and self-reported income of subjects are reported in Table 2. As expected, the sample is better educated and wealthier than the communities from which it was recruited, in part because home ownership was a requirement for participation.

Materials

Each subject received a four-page, 8½"-by-11" pamphlet. The first page of the pamphlet was a cover letter stating that the task was to "tell us how you think you would feel in this situation and what you think you would do." Page two and

Table 2
Education and Income for Study Communities
and Study Participants

Community	High school graduate or higher (%)	Four-year college graduate or higher (%)	Household income
Irmo, SC	94.6	35.9	40,681 (median)
Irmo sample (N = 668)	98.5	53.3	54.1% ≥ $50,000
Cary, NC	94.9	48.8	45,301 (median)
Cary sample (N = 734)	98.6	60.5	67.5% ≥ $50,000

Note: Education figures based on persons 25 years and over.

the top of page three contained the particular news story the subject was asked to read. The story was followed by various types of information designed to help the subject interpret his or her radiation level. The ten different pamphlets used appear in Appendix B.

News Stories

Three stories were created to describe situations in which radiation within homes posed a threat of unknown magnitude to residents of the Washburn Circle section of Middletown. The stories were presented in newspaper columns and emulated newspaper writing style. In the low-outrage, high-risk story ("Radon Risk to Middletown Homes"), the radiation came from radon produced by naturally occurring uranium. In the high-outrage, low-risk story ("Nuclear Waste Contaminates Middletown Homes"), the radiation came from sand that had absorbed radioactivity when it covered a storage site for spent nuclear power fuel rods, sand that had then been used illegally to make concrete for the homes' foundations. In the low-outrage, low-risk story ("Radiation in Middletown Homes"), the source of radiation was sand used to make concrete for the homes' foundations that was only later learned to contain naturally occurring uranium.

The key actors in all three stories were Charles Schmidt of the State Department of Environmental Protection (DEP); Dr. Susan Baxter, Director of the Middletown University Health and Safety Program; and Harriet Mossman, chair of the Washburn Circle Neighborhood Association. All three stories began with the sentence, "Homeowners in the Washburn Circle section of Middletown will find out soon just how radioactive their homes are." The radiation was described as having been discovered accidentally by a sixth grade student who was conducting a science project on radiation. The initial assessment of the radiation, provided by Schmidt of DEP, was that there is "only a very small health risk." The stories state that Dr. Baxter was carrying out measurements of home radiation levels independent of the state Department of Environmental Protection. According to the stories, each homeowner who agreed earlier to have measurements taken was about to receive a written report. Baxter was quoted as saying that "the level of radiation, and therefore the level of risk, varied from one home to the next." The stories concluded with six nearly identical paragraphs about the way in which radiation accumulates in homes, the reason why radiation increases the risk of lung cancer ("a disease considered virtually incurable and almost always fatal"), the factors that influence the level of risk, and the possibility of remediation.

Low-outrage, high-risk news story. In this story (839 words), the source of the radiation was radon produced by naturally occurring uranium. Mossman was described as saying that "we don't expect to find any serious problems, but we want to be sure," that the neighborhood association is "very grateful to the DEP and the University for moving so quickly," and that "there are no villains here.... It's just a fact of nature and we know how to deal with it."

High-outrage, low-risk news story. In this story (921 words), the Wellspring Corporation was paid $2 million by an electric utility to take sand from a nuclear fuel storage site and leave the sand at a special disposal facility for radioactive waste. Instead, Wellspring used it to make concrete for the foundations and porches of the homes it was building in Washburn Circle. According to the story, legal recourse probably would not help Washburn Circle residents because the Wellspring Corporation has gone bankrupt.

In the story Mossman made several statements indicative of distrust, fear, and anger. In response to Schmidt's suggestion that the risk appears to be very small, she replied, "We're *not* so sure the risk is small.... The numbers may turn out much higher than Mr. Schmidt is admitting." Later she said that "whatever the numbers turn out to be, Washburn Circle residents are angry, and we will stay angry until the contamination is removed and our health is protected." She added that "for as much as 15 years we have let our kids play on radioactive front porches and have literally built our lives on radioactive foundations. Who knows what cancers lurk in our futures and our children's futures?"

The story emphasized the impartiality of the soon-to-arrive home radiation reports by having Dr. Baxter say, "We recognize that homeowners need a source of information they can trust." Furthermore, Mossman thanked Baxter, saying, "We didn't know where to turn for help and are pleased that the data will come from someone who has no axe to grind."

Low-outrage, low-risk news story. This story (839 words) was essentially the same as the low-outrage, *high*-risk story, except that the radiation was described as coming from uranium rather than radon. The reason for avoiding the term "radon" was the possibility that media coverage over the last few years, during which time radon has been labeled as a serious problem, might have made it difficult for subjects to believe that the low levels they were being assigned in these conditions did pose the negligible risk indicated by the information provided.

Risk Information

Immediately after the news story, instructions asked subjects to imagine living in one of the homes in Washburn Circle and to read "their" home radiation report, which followed.

The report, labeled as coming from the Middletown University Health and Safety Program, described "the level of extra radiation in your principal living area from the [experimental source]" as "___ picoCuries of radiation per liter of air (pCi/L)" (where the blank was replaced with the actual level for each condition, as seen in Table 1). This information was provided in all conditions.

The "base risk" treatment then translated the radiation level into a risk estimate. In the 8 pCi/L conditions, for example, a paragraph stated: "To interpret this result, it may help you to know the health risk caused by being exposed to this amount of radiation. If 1,000 people lived for 70 years in homes with 8 picoCuries of radiation per liter of air, about 40 of them would be expected to contract lung cancer as a result of this exposure. In other words, for every 1,000 people exposed to this level of radiation over a lifetime, 40 more of them, on average, would get lung cancer than if they were not exposed to the radiation." Lung cancer probability information was provided in eight of the ten conditions, all except the two "compare to normal" conditions.

Comparisons to normal background levels took the following form: "To interpret this result, it may help you to know that the average outdoor background level of breathable radiation in the United States, from all sources, is approximately 0.4 picoCuries of radiation per liter of air. The radiation exposure in your house from [the experimental source] is thus 20 times greater [or 200 times less] than the average outdoor background level." This information was provided only in the two "compare to normal" conditions, the two conditions in which lung cancer probability information was *not* provided.

The "base risk + chart" treatment included a chart containing a variety of information: (1) A ladder of concentrations that started at 0.0 pCi/L and stopped at 10 pCi/L, with each pCi/L labeled and a tick mark every 0.1 pCi/L; (2) Information about the cancer risk at 11 different levels, in terms of the number of excess lung cancer deaths for 1,000 people exposed to this level over a lifetime; (3) The EPA action guideline for radon ("at 4 pCi/L EPA recommends that you reduce your home radiation level"); (4) Comparisons to three other causes of death (stroke, diabetes, and colon/rectal cancer)[10]; and (5) Comparisons of three radiation levels to normal background ("average outdoor radon [or radiation] level," "15 times average outdoor radon [or radiation] level," and "25 times average outdoor radon [or radiation] level"). A few sentences explained how to use the chart. Except for the words "radon" or "radiation" to match the story, the same chart was used with all stories. A rubber stamp was prepared that contained an arrow and the phrase "YOUR LEVEL." When subjects received a chart, the stamp pointed to the spot on the risk ladder that represented their radiation report, in red ink. For subjects assigned 8 pCi/L, the red arrow pointed four-

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[10]Research conducted expressly to assist in the revision of the *Citizen's Guide to Radon* (Weinstein and Sandman, 1991) suggested that the choice of comparison hazards was not an important factor.

fifths of the way up the ladder; for subjects assigned .002 pCi/L, it pointed just above the 0.0 point at the bottom of the ladder. This chart was provided as a supplement to the lung cancer probability information in three conditions.

Feedback Questionnaire

The feedback questionnaire is reproduced in Appendix C. It appeared on a separate sheet and was identical in all conditions.

To check for unintended differences in understandability, the questionnaire asked how clear the newspaper article was (1 = very confusing; 4 = very clear) and how clear the information was about the seriousness of the radiation level (1 = very confusing; 4 = very clear).

Three questions were written to assess the effects of the outrage manipulation: "How angry would you feel to find this level of radiation?" (1 = not at all angry; 5 = extremely angry); "From what you have read, do you think you could trust the risk information provided to you by Dr. Baxter of the University Health and Safety Program?" (1 = definitely could trust; 5 = definitely could not trust); and "From what you have read, do you feel that Charles Schmidt, the State DEP spokesperson quoted in the newspaper article, cares about the health and safety of your neighborhood?" (1 = cares a lot; 5 = doesn't care at all).

Four questions were employed to measure perceived threat: "How would you describe the danger from the radiation level found in your Washburn Circle home?" (1 = no danger; 6 = very serious danger); "If you continued to live in your Washburn Circle home and did nothing about the radiation, what is your impression of the chance that the radiation would give you lung cancer?" (1 = no chance; 7 = certain to happen); "How concerned would you feel finding this level of radiation?" (1 = not at all concerned; 5 = extremely concerned); and "How frightened would you feel finding this level of radiation?" (1 = not at all frightened; 5 = extremely frightened).

Also, four questions were used to measure action intentions: "Given what you have learned about the risk, do you think it would be worth your spending $300 to reduce the risk to zero?" (1 = definitely would not spend $300; 5 = definitely would spend $300); "Given what you have learned about the risk, do you think it would be worth your spending $3,000 to reduce the risk to zero?" (1 = definitely would not spend $3,000; 5 = definitely would spend $3,000); "If you learned that it wasn't possible to reduce the radiation in your home, would that make you want to move away?" (1 = would not feel any interest in moving away; 5 = would insist on moving away); and "Imagine that you were looking for a new home in a new neighborhood, and found that it had this level of radiation (the level we told you was found in your home). Would this reduce your interest in buying this new home?" (1 = would not be at all reluctant to buy a home with this level of radiation; 5 = definitely would not buy a home with this level of radiation).

A final section asked subjects their sex, education, and household income, and the amount of time they spent reading the booklet and filling out the questionnaire.

Procedure

The study was described on the telephone as focusing on how homeowners make decisions about environmental risks. The caller told the homeowner that people were being asked "if they would read a brief, one-page news article about an environmental problem and answer a short questionnaire to tell us what they would do if they were in that situation." The sum of $1 was offered as a thank you for their help.

The four-page pamphlet (including news story, risk information, and instructions), two-page questionnaire, and a stamped, self-addressed envelope were mailed to each subject who agreed to participate. The questionnaire contained a printed code that identified which pamphlet had been mailed (i.e., the subject's condition). Another number served as a subject identification code. Reminder calls (and additional mailings if needed) were made to increase response rates. All data collection took place in June, 1993.

RESULTS

Scale Construction

To measure perceived threat and action intentions, answers to the four threat questions were added together and answers to the four action questions were added together. Scale reliabilities were calculated after standardizing the variables to the same mean and variance within each condition. The reliability coefficient (Cronbach's alpha) of the threat perception scale was found to be .90 and the reliability of the action intentions scale was .86. Although the two scales were strongly correlated with each other ($r = .72$ for the pooled, within-condition correlation coefficient), the items within each scale correlated more highly with one another than with the items in the other scale. This relationship is indicated by the fact that a scale created by combining all eight items had a reliability of .92, scarcely greater than the figures for the two separate four-item scales. Consequently, the two scales were kept separate.

Analysis Strategy

Because the low-outrage, low-risk story lacked "alternate risk" and "compare to normal" conditions, the experimental design was not a complete 3 (stories) × 4 (treatments) factorial. Consequently, analyses could not be based on a simple, two-factor analysis of variance. Instead, the analysis strategy was to look first at the low-outrage, high-risk and high-outrage, low-risk stories in a simple 2 (stories) × 4 (treatments) analysis of variance. If the analysis of variance indicated that there were *significant* differences among treatments, the treatments were compared, pairwise, with post-hoc tests using Tukey's HSD criterion, with a significance criterion of .02 to minimize false positives. These post-hoc tests were conducted either across both stories when no story × treatment interactions were found or within each story when significant interactions were present. Additional calculations examined the effect of the outrage manipulation at a constant low-risk level by comparing the "base risk" and "base risk plus chart" conditions for the high-outrage, low-risk story and the low-outrage, low-risk story, in a simple 2 (stories) × 2 (treatments) analysis of variance. These two analyses will be referred to as the "2 × 4 analysis of variance" and the "2 × 2 analysis of variance," respectively. The mean values of the main dependent variables are shown in Table 3 for each condition.

Manipulation Checks

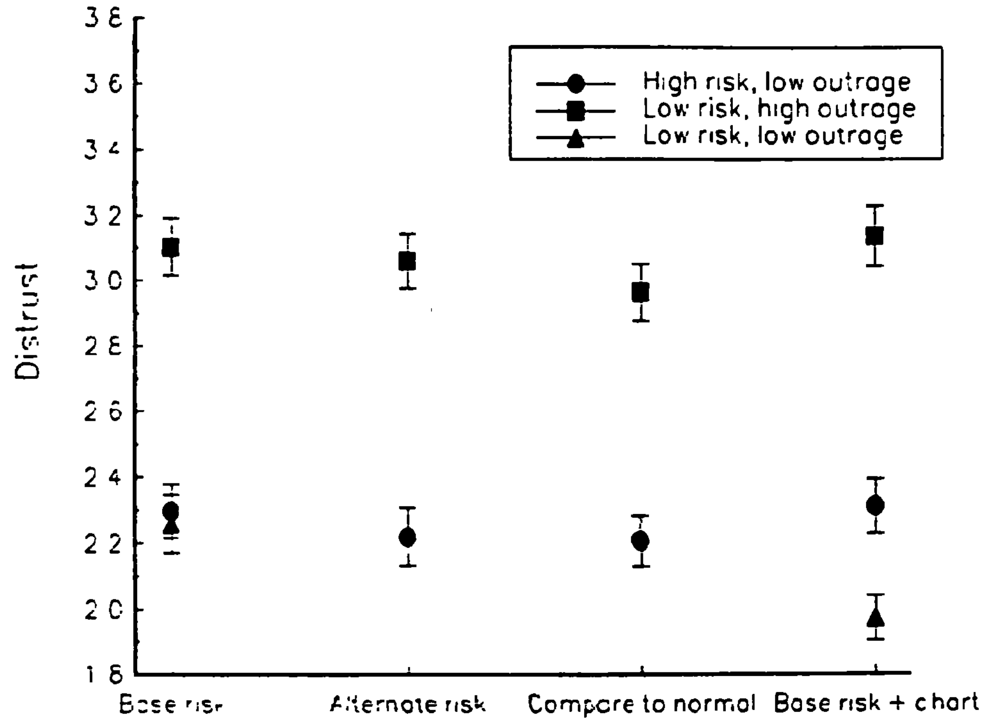
If the outrage manipulation were successful, distrust of the DEP spokesman, Schmidt, and anger at the situation would be much greater in the high-outrage conditions than in the low-outrage conditions. The mean levels of distrust of Schmidt are shown in Figure 1.[11] The 2 × 4 analysis of variance confirms that

Table 3
Mean Values of Dependent Variables

Condition	Article clear	Risk report clear	Threat	Action intentions	Anger	Distrust Baxter	Distrust Schmidt
Low Outrage, High Risk ("Radon")							
Base risk (N=131)	3.46	3.20	13.88	14.74	2.31	2.15	2.30
Alternate risk (N=135)	3.47	3.36	16.16	16.00	2.40	2.24	2.22
Compare to normal (N=136)	3.49	3.01	16.45	15.76	2.64	2.29	2.21
Base risk + chart (N=139)	3.51	3.45	15.76	15.81	2.57	2.18	2.31
High Outrage, Low Risk ("Nuclear Waste")							
Base risk (N=149)	3.36	3.26	12.57	14.72	3.46	2.28	3.10
Alternate risk (N=153)	3.36	3.32	11.99	14.38	3.42	2.32	3.06
Compare to normal (N=131)	3.34	3.20	10.94	12.24	2.75	2.38	2.96
Base risk + chart (N=137)	3.42	3.48	10.45	12.64	2.91	2.24	3.13
Low Outrage, Low Risk ("Radiation")							
Base risk (N=148)	3.48	3.37	9.76	11.82	1.92	2.17	2.26
Base risk + chart (N=143)	3.56	3.48	7.63	9.14	1.48	2.02	1.97

[11]Error bars in the figures represent the standard error of the mean (i.e., the standard deviation of an individual value divided by the square root of the sample size). For two means to be significantly different at the .02 level in a simple t-test, the difference between the means would have to be at least 3.3 times the standard error (assuming both means had the same standard error).

Figure 1
Effects of Condition on Distrust of DEP's Schmidt



distrust was much greater in the high-outrage conditions. The effect of story was highly significant, $F(1, 1074) = 177.7, p < .0001$. There was no treatment effect nor any interaction between story and treatment (p's > .2).

Anger revealed a more complicated pattern, as shown in Figure 2. In the 2 × 4 analysis of variance, there was a large effect of story, $F(1, 1102) = 68.8, p < .0001$, with more anger overall in the high-outrage conditions. There was no treatment effect, $F(3, 1102) = 1.8, p = .15$, but there was a highly significant story × treatment interaction, $F(3, 1102) = 10.4, p < .0001$. Further comparisons among the treatments associated with each story revealed no differences in anger among the low-outrage, high-risk conditions, $F(3, 533) = 1.65, p = .18$, but a large difference among the conditions with the high-outrage, low-risk story, $F(3, 562) = 11.6, p < .0001$. In particular, subjects who read the high-outrage, low-risk story experienced significantly less anger with the "compare to normal" treatment and the "base risk + chart" treatment than with the treatments with only risk numbers ("base risk" and "alternate risk"). The same finding was observed for the low-outrage, low-risk story: The anger of subjects in the "base risk + chart" condition was significantly lower than in the "base risk" condition without the chart, $F(1, 289) = 14.4, p < .0002$.

These results indicate effects on anger of both outrage and perceived risk. The high-outrage stories produced a high level of anger, but communications that did a good job of convincing subjects that the risk was low (as described later) decreased this anger substantially. Both low-outrage stories had low levels of anger in the "base risk" condition. Communications that improved subjects' understanding of the risk diminished anger still further if the risk was low, but such communications did not decrease anger if the risk was high. It might be hypothesized from an examination of the low-outrage, high-risk results that low outrage helped prevent a high risk level from producing anger. Although we did not include a high-outrage, high-risk story, one might guess that improved understanding of the risk in this case would actually increase anger.

As intended, distrust of the independent expert, Dr. Baxter, was low (see Figure 3). The 2 × 4 analysis of variance showed a very small difference between the low-outrage, high-risk and the high-outrage, low-risk stories, $F(1,1098) = 4.05$, $p < .05$, with mean values of 2.21 and 2.31 for these two stories, respectively. There were no significant treatment effects or story × treatment interactions, p's > 15. The difference in distrust between the high-outrage, low-risk and the low-outrage, low-risk stories was not statistically significant, $p > .1$.

Other calculations examined the perceived clarity of the news stories themselves and of the risk information provided. The 2 × 4 analysis of variance showed that the low-outrage, high-risk story was rated as clearer than the high-outrage, low-risk story, $F(1, 1092) = 8.80, p = .003$. The difference between the

Figure 2
Effects of Condition on Anger

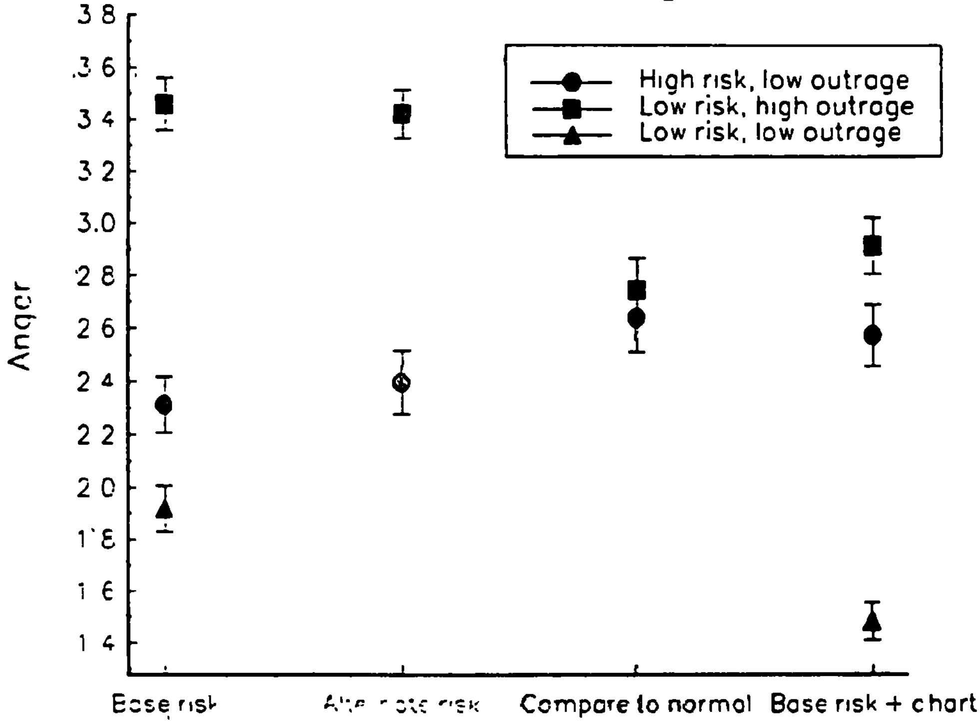
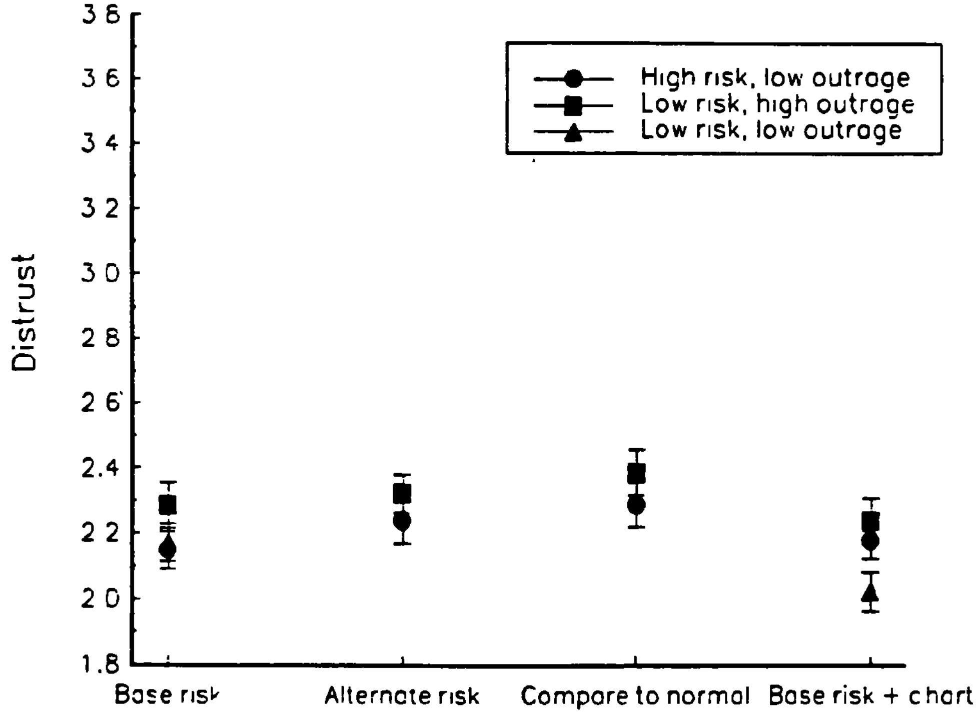


Figure 3
Effects of Condition on Distrust of Dr. Baxter



means, however, was quite small: 3.48 vs. 3.37 for the low-outrage, high-risk and the high-outrage, low-risk stories, respectively. Apparently, the description of the illegal activities of Wellspring and its president was slightly confusing. There were no treatment effects or story × treatment interactions, p's > .5.

In contrast to the ratings of the clarity of the news stories, the 2 × 4 analysis of variance showed significant differences among treatments in how clearly the seriousness of the risk was explained, $F(3, 1103) = 9.28$, $p < .0001$. The "base risk + chart" treatment (mean = 3.46) was judged to be clearest. Overall, it was rated significantly higher than both the "compare to normal" treatment (mean = 3.10) and the "base risk" treatment (mean = 3.23), p's < .02. (The "alternate risk" treatment and the "base risk" treatment were identical except for the risk levels, and would be expected to receive the same ratings for clarity, but the former was rated slightly higher for both the low-outrage, high-risk and the high-outrage, low-risk stories.) There were no differences among the news stories, $p > .2$, and there were no significant story × treatment interactions.

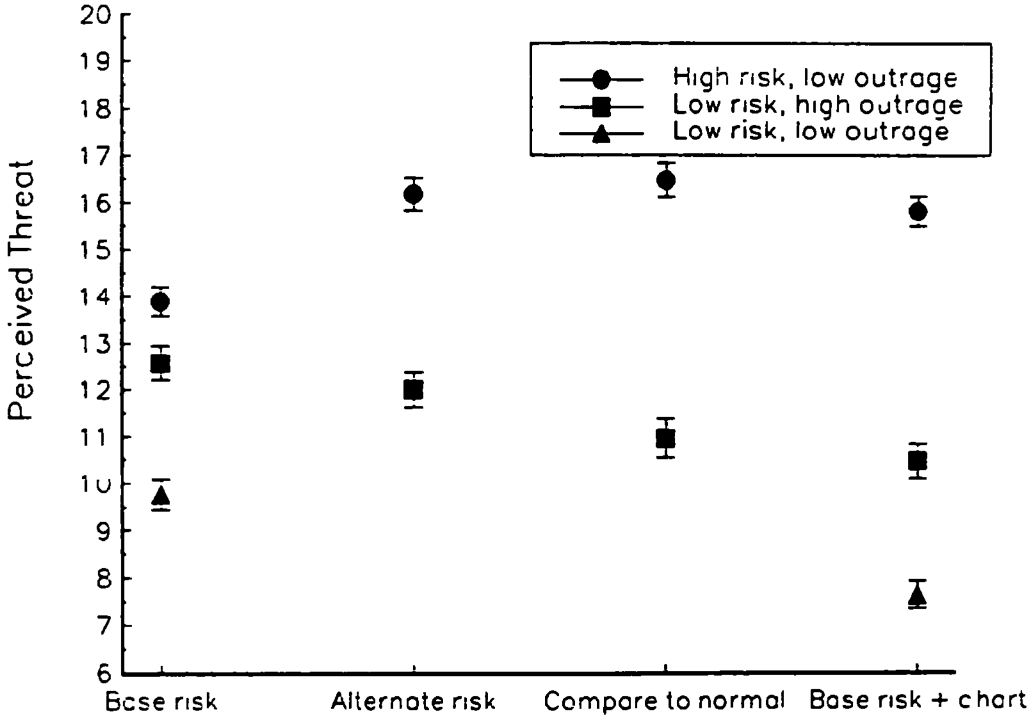
Effects on Perceived Threat

The 2 × 4 analysis of variance of the low-outrage, high-risk and the high-outrage, low-risk stories revealed a significant story effect, $F(1, 1087) = 253.0$, $p < .0001$, a significant treatment effect, $F(3, 1087) = 14.12$, $p < .0001$, and a significant story × treatment interaction, $F(3, 1087) = 3.02$, $p < .05$.

Figure 4 shows clearly that, overall, the radon story was correctly recognized as presenting a greater threat than the other two stories. The difference was not always as great as might be desired, however. The perceived threat in the high-outrage, low-risk "base risk" condition was just 1.3 scale points less than the perceived threat in the low-outrage, high-risk "base risk" condition, despite the fact that the risk of lung cancer was described as being 1-in-100,000 in the former and 40-in-1,000 in the latter, a 4,000× difference. The difference in perceived threat between these two base risk conditions was minimal, $F(1, 273) = 3.50$, $.05 < p < .1$.

Post-hoc analyses were conducted for the treatments within each story. These calculations showed that for the low-outrage, high-risk story, the "base risk" condition was viewed as significantly less threatening than all the other conditions (which did not differ from one another for this story). Comparing the "base risk" condition (with a lung cancer risk of 40-in-1,000 or 4%) and the "alternate risk" condition (with a lung cancer risk of 400-in-1,000 or 40%), we see an increase in the perceived threat scale from 13.9 to 16.2. Thus a 10-fold increase in risk produced an increase on the perceived threat scale of 2.3 points. Roughly the same increase in perceived threat was accomplished merely by describing the

Figure 4
Effects of Condition on Perceived Threat



radon level as 20 times normal background levels (without providing any risk statistics) or by adding the chart to the risk statistics in the "base risk" condition.

For the high-outrage, low-risk story, post-hoc tests showed no significant difference between the "base risk" condition and the "alternate risk" condition (with a risk ten times smaller). In other words, people reacting to a risk of 1-in-100,000 did not respond differently than those reacting to a risk of 1-in-1,000,000. However, the conditions that compared the risk to normal levels or added the chart to the risk probability information were viewed as presenting significantly less risk than the "base risk" condition. The mean on the perceived threat scale declined from 12.6 in the "base risk" condition to 10.9 for the "compare to normal" condition and to 10.4 for the "base risk + chart" condition, decreases of 1.7 points and 2.2 points, respectively. In a high-outrage, low-risk situation, in other words, comparisons to background and the risk chart reduced perceived threat more than a 10-fold decrease in the actual probability of lung cancer.

The 2 × 2 analysis of variance involving the high-outrage, low-risk and the low-outrage, low-risk stories showed a strong story effect, $F(1, 568) = 68.4$, $p < .0001$, a strong treatment effect, $F(1, 568) = 38.9$, $p < .0001$, and no interaction, $p > .9$. There was a 2.9-point decrease in perceived threat when outrage elements were absent from the story, an effect far greater than the effect of decreasing the actual risk by a factor of ten. The treatment effect was also substantial. Adding a risk chart to the "base risk" condition reduced the perceived threat scale from 9.8 to 7.6 for the low-outrage, low-risk story, and from 12.6 to 10.4 for the high-outrage, low-risk story, reductions of 2.2 points in both cases. The absence of an interaction effect shows that the chart was just as beneficial in the high-outrage condition as in the low-outrage condition. In other words, the outrage effect and the treatment effect were independent and additive. With or without the risk chart, subjects who read the low-outrage story perceived less threat than those who read the high-outrage story, though the "actual" (stated) risk level was the same. And regardless of which story they read, high-outrage or low, subjects who received the risk chart perceived less threat than subjects who received just their own risk probability information.

Effects on Action Intentions

The findings for action intentions were similar to those for perceived risk. The 2 × 4 analysis of variance of the low-outrage, high-risk story and the high-outrage, low-risk story revealed a significant story effect, $F(1, 1081) = 76.2$, $p < .0001$, a significant treatment effect, $F(3, 1081) = 11.22$, $p < .0001$, and a significant story × treatment interaction, $F(3, 1081) = 5.00$, $p < .002$.

Figure 5 shows that the low-outrage, high-risk story ("radon") produced greater action intentions overall than the other two. But in the "base risk" conditions – that is, with risk numbers only – there was no difference whatsoever between subjects who read the low-outrage radon story and faced a high risk of 40-in-1,000 and those who read the high-outrage nuclear waste story and faced a low risk of 1-in-100,000.

Post-hoc analyses were conducted within each hazard. For the low-outrage, high-risk story, these calculations showed that the "base risk" condition led to significantly lower action intentions only in comparison with the 10-fold greater "alternate risk" condition. The comparisons to normal and the risk chart yielded slightly lower action intentions than the "alternate risk" treatment. These were higher, but not significantly higher (at $p < .02$) than the "base risk" condition. For subjects who read the low-outrage, high-risk radon story, in other words, no explanation significantly increased action intentions above the action intentions produced by the bare-bones risk information – though an increase in the risk from 40-in-1,000 to 400-in-1,000 did increase action intentions.

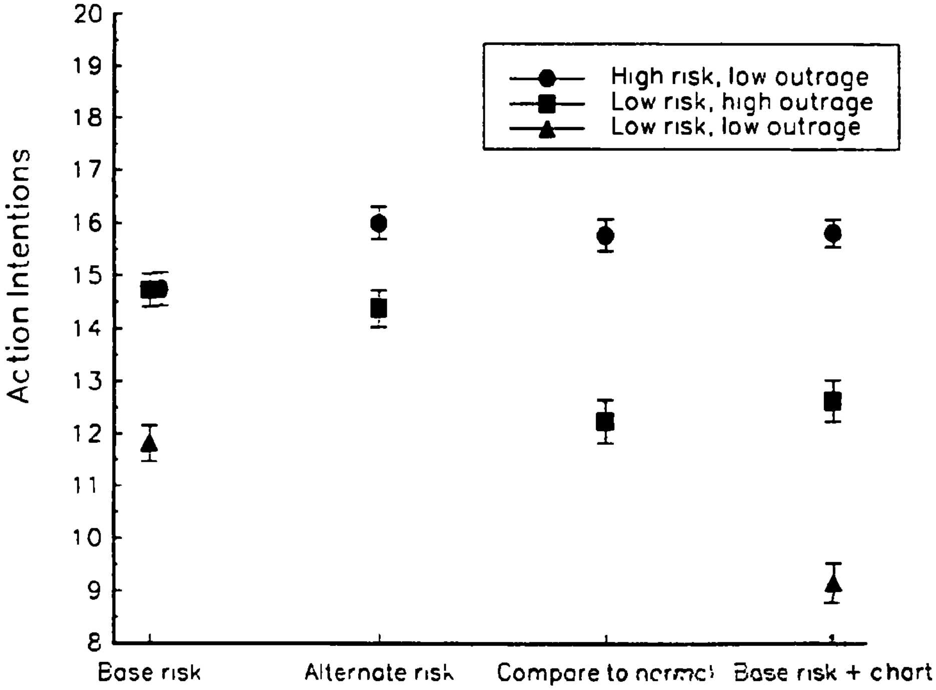
For the high-outrage, low-risk story, in contrast, there was no difference in action intentions between subjects in the 1-in-100,000 "base risk" condition and those in the 1-in-1,000,000 "alternate risk" condition. However, the comparisons to normal and the risk chart substantially decreased action plans. Action plans in these two conditions were significantly lower than in both the "base risk" and the "alternate risk" condition, and not significantly different from one another.

The 2 × 2 analysis of variance involving the high-outrage, low-risk and the low-outrage, low-risk stories again showed a strong story effect, $F(1, 562) = 78.5$, $p < .0001$, a strong treatment effect, $F(1, 562) = 43.3$, $p < .0001$, and no interaction, $p > .4$. There was a 3.2-point decrease in action intentions when outrage elements were absent from the story, an effect far greater than decreasing the actual risk by a factor of ten. And there was a 2.4-point decrease in action intentions when a risk chart was added to the risk probability information provided to subjects. The absence of interactions between story and treatment shows that the chart was just as influential in reducing action intentions for the high-outrage story as for the low-outrage story. Once again the two effects were independent and additive.

Relationships of Anger and Distrust to Perceived Threat and Action Intentions

Additional calculations revealed the close association between anger and both threat perceptions and action intentions. The correlations of anger with perceived threat averaged .70 over the ten experimental treatments, and the correlations with action intentions averaged .58, both highly significant.

Figure 5
Effects of Condition on Action Intentions



With regard to DEP's Schmidt, the 2 × 4 analysis of variance indicated a main effect for gender $F(1,1054) = 17.32$, $p < .0001$. Women were more distrustful of Schmidt than men (means of 2.80 and 2.52, respectively). There was also a significant gender × story interaction, $F(1,1054) = 12.31$, $p < .0001$. Again, women were more distrustful of Schmidt than men in the high-outrage nuclear waste story (means of 3.26 and 2.82, respectively). On the other hand, men were more distrustful of Schmidt than women in the low-outrage radon story (means of 2.25 and 2.18, respectively). The 2 × 2 analysis of variance revealed no main effect of gender on trust for Schmidt, but a marginal gender × story interaction $F(1,550) = 4.52$, $p < .04$. Once again, women were more distrustful than men in the high-outrage nuclear waste story (means of 3.22 and 3.00, respectively), while men were more distrustful than women in the low-outrage radiation story (means of 2.18 and 2.04, respectively).

Within the various stories there were no main effects of education or income and no interactions of treatment with gender, education, or income.

The 2 × 4 analysis of variance showed a main effect of gender on anger $F(1,1074) = 37.51$, $p < .0001$. Again, women were angrier than men (means of 3.05 and 2.57, respectively). Similarly, the 2 × 2 analysis of variance showed a main effect of gender on anger $F(1,560) = 15.48$, $p < .0001$, with women angrier than men (means of 2.61 and 2.24, respectively).

Subjects with less education were more angry than those with more education (p's $< .01$ in both the 2 × 4 and the 2 × 2 analyses of variance). These was no significant effect of income. In neither case were there any significant interactions of gender, education, or income with story or treatment.

Time Spent Reading the Stories and Answering the Questionnaire

Most respondents took between 10 (coded as 1) and 15 (coded as 2) minutes to complete the task (mean coded value of = 2.45). To examine the effects of this variable, it was first divided into two categories, using the median answer as a cutting point. Analysis of variance calculations were carried out using this categorical variables, plus gender, story, and treatment, in a factorial design. These calculations revealed a main effect of time spent on the task. People who took longer to comple the experiment perceived a significantly greater threat.

A one-way analysis of variance, across all ten experimental conditions, showed no significant differences in the time needed to complete the experiment. A 2 (gender) × 10 (condition) analysis of variance revealed a main effect of gender, $F(1,1061) = 63.36$, $p < .001$, with females taking more time to complete the experiment than men (means of 2.52 and 2.36, respectively). Across all ten conditions there was also a significant negative correlation between education and time, $r = -.16$, $p < .0001$. Partial correlations controlling for the effects of gender and education showed a significant positive association between the amount of time spent completing the experiment and both perceived threat, $r = .11$, $p < .0001$, and inclination to take action, $r = .08$, $p < .002$.

DISCUSSION

The research reported here, like the research in the first two budget periods, used responses to hypothetical situations. Subjects were asked to read a hypothetical news story, then examine a hypothetical test result for "their" home, and finally complete a questionnaire about their response to the hypothetical risk. It is impossible to say how realistic subjects found these simulations and how realistically they responded to them. It seems likely that the effects of outrage were diminished by the hypothetical nature of the hazards, and that the effects of risk magnitude and of various ways of explaining risk magnitude – especially in the presence of high outrage – were augmented. That is, we would expect subjects to be more attentive to risk magnitude information and less liable to outrage in this study than they would be in a real situation. But no research findings back this supposition.

In addition, real community hazard situations develop over days, months, or even years; the study compressed these histories into written materials that take only a few minutes to read. Prolonged exposure to a risk controversy probably makes people more responsive to outrage factors than they were in this research. We do not know whether it might make them more or less responsive to explanations of risk magnitude. No studies bear on this point either.

The present simulation research strategy has obvious advantages in terms of feasibility, efficiency, and the avoidance of ethical problems. Nonetheless, the time is approaching when these findings need to be confirmed in situations where citizens are making decisions about real hazards.

The Effects of Comparisons to Normal Background

The most surprising finding of this research was the powerful impact of comparisons to normal background levels on threat perceptions and action intentions. The "compare to normal" treatment was originally intended as a baseline control condition, since no information about the size of the risk was provided. The comparison to normal background was added to make the treatment more realistic for subjects.

Despite having no information at all about the likelihood of harmful consequences, subjects responded strongly to the information that their radiation exposure in the low-outrage, high-risk story ("radon") was 20× higher than normal background radiation, or that their radiation exposure in the high-outrage, low-risk story ("nuclear waste") was 200× lower than normal background. Compared to the "base risk" condition, comparisons to normal increased perceived threat for the radon story and decreased both perceived threat and action intentions for the nuclear waste story. In other words, when subjects were given a comparison of the risk from the situation in the news story to the risk from their normal background exposure, this comparison did a better job than risk information itself in helping them respond in proportion to the actual risk. Phrased another way, comparisons to normal background helped subjects respond <u>more</u> to the high-risk radon situation even though the outrage was small, and respond <u>less</u> to the low-risk nuclear waste situation even though the outrage was great. The effect of the comparison to normal was equal to the effect of a 10-fold increase in risk for radon; it was greater than the effect of a 10-fold decrease in risk for nuclear waste.

The impact of comparisons to normal background on anger is also worth noting, since this appears to be an effect on outrage. Subjects in the high-outrage "nuclear waste" conditions were understandably angry. Their anger was reduced far more by the knowledge that the situation posed a risk 200× less than normal background than by the knowledge that the risk posed was a mere 1-in-100,000 or even a mere 1-in-1,000,000. In other words, the illegal and intentional use of radioactive sand in construction of their homes' foundations generated far less anger among subjects when it was described as a risk 200× less than normal background radiation than when it was described as a 1-in-1,000,000 risk.

The potency of the comparison to normal background and its symmetry (that is, its effectiveness in both low-outrage, high-risk situations and high-outrage, low-risk situations) suggest that it may be a valuable piece of information to include in any risk communication – at least when the information is available. In the research reported here, background levels were known and could be expressed in the same units as the levels from the hypothetical situation: picoCuries of radiation per liter of breathable air. In many situations such a direct comparison to normal background is not possible.

In effect, people may view the normal background exposure as the maximum safe exposure, regardless of the level of risk it presents. This exposure can then serve as an anchor or comparison standard (Slovic, Fischhoff, & Lichtenstein, 1982) for their risk judgments, with higher levels seen as "unsafe" and lower levels as "safe." It is important to note that comparisons to normal can be very misleading. If a hazardous substance is extremely rare in nature, one can have an exposure that is many times background but still so low that the risk it presents is vanishly small.

The study also leaves unclear the impact of comparisons to normal background for risks that are less serious than 20× greater than background but more serious than 200× smaller than background. Suppose a neighborhood's exposure to effluent from a nearby factory is equal to normal background for a particular chemical; the factory thus doubles the neighborhood's total exposure to that chemical. Deciding that 20× background is serious or that 200× less than background is trivial is a comparatively easy decision; how would citizens interpret an exposure that was roughly the same as background? Would such information increase or decrease threat perceptions and action intentions? Or would the direction of its impact depend on other factors? Or would it have no impact at all? The answers to these questions are not known.

In the research reported here, the low-outrage, low-risk story did not include a "compare to normal" condition, so it is not possible to say how this treatment would fare when both outrage and risk are low. Given its success under low-outrage, high-risk and high-outrage, low-risk conditions, however, it seems reasonable to surmise that it would probably work well in low-outrage, low-risk situations as well.

It should not be forgotten that a comparison to background does not constitute risk information. For some hazards, normal background levels are sufficient to constitute a meaningful health risk, and even a small increment would be unwise if it were preventable. For other hazards, the risk due to normal background exposure is negligible, and an exposure many times background would still be negligible. It is not easy to find two agents known to be harmful such that an exposure of 200× less than background to one is more serious than an exposure of 20× greater than background to the other. But with lower multiples, it would not be hard to find examples where comparisons to background give impressions contrary to the actual risk magnitudes, and are thus misleading.

Nonetheless, the finding is clear. When a risk adds only a very small percentage to normal background, people readily conclude that it is not too serious; when it adds a large multiple of normal background, they readily conclude that it is quite serious. At least with the large multiples and small fractions of "normal" studied here, information about how a target risk compares to normal background levels has more impact on perceived threat and action intentions than numbers describing the odds of experiencing harmful effects.

The Effects of the Risk Chart

Similar effects were achieved by supplementing the "base risk" condition with a chart that included a risk ladder (with the target risk high on the ladder for the "radon" story, low on the ladder for the "nuclear waste" and "radiation" stories), risk comparisons, and a recommended action standard. The chart decreased perceived threat in both low-risk situations (the high-outrage "nuclear waste" situation and the low-outrage "radiation" situation), while it increased perceived threat in the high-risk "radon" situation. The effects of the chart were roughly equal to the effects of comparisons to normal background – equally effective as a 10× increase in actual risk for radon, and more effective than a 10× decrease in actual risk for nuclear waste. Similarly, the chart decreased action intentions for "nuclear waste" and "radiation," though the effect on action intentions for "radon" was not significant.

The "base risk + chart" treatment was initially conceptualized as a "maximum impact" treatment, incorporating all the approaches found effective in the previous research.[12] Note, however, that it did include some of the comparison information that proved so effective in the "compare to normal" treatment. Comparisons to normal background were included on the chart, along with comparisons to the risk from stroke, colon/rectal cancer, and diabetes. At the top of the risk ladder, the chart showed "25 times average radon [or radiation] level"; a little over halfway up the ladder, the chart showed "15 times average radon [or radiation] level"; near the bottom of the ladder, it showed "average outdoor radon [or radiation] level."[13] Thus, a subject who studied the chart carefully could deduce that his or her risk was far above normal background for the radon situation, and far below normal background for the other two. This information was far less emphasized, however, than it was in the "compare to normal" treatment.

No experimental treatment combined the "compare to normal" and the "base risk + chart" treatments. We know that either comparisons to normal background or risk information supplemented with a risk ladder, risk comparisons, and an action standard works better than risk information alone – whether the goal is to increase attention to a big risk or decrease concern about a small one. We do not know if the combination of an explicit comparison to normal background plus the risk chart would work better than either alone, nor can we be

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[12]Except for the recommended action standard at 4 picoCuries per liter, the "base risk + chart" treatment did not include action advice at other risk levels, though the research in the first budget period showed such advice at various levels to be helpful. Advice was kept off the chart partly to avoid excessive clutter and partly because action advice for radon is largely a function of mitigation feasibility, a variable that we did not wish to add to the study.

[13]For the radon story, the term used was "radon." For the other two stories, it was "radiation."

certain that the risk chart would be effective without the comparisons to normal background embedded in it.

This study had no true baseline "control" condition. The treatment that was supposed to have constituted the control – comparisons to background without risk information – turned out to be just as effective as the most effective collection of risk information identified in previous research. The "base risk" treatment – in which subjects were told simply that their risk was either 40-in-1,000 (radon) or 1-in-100,000 (nuclear waste and radiation) – was thus the only baseline available. The "base risk + chart" condition constituted a significant improvement over this baseline. For all three hypothetical situations, the chart significantly influenced threat perceptions – decreases when the actual risk was low, increases when it was high. It similarly decreased action intentions when the actual risk was low, though the effect on action intentions for the high-risk "radon" story was not significant.

The Effects of Risk Magnitude

The research in the second budget period demonstrated an effect of risk magnitude on risk perception. This finding was replicated in the research reported here.

Although the study had no true baseline control, we can compare responses to the low-outrage, low-risk situation and the low-outrage, high-risk situation to get a measure of risk effects independent of how the risk was explained. For both the "base risk" treatment and the "base risk + chart" treatment (the only two used for the low-outrage, low-risk story), subjects experienced higher threat perceptions and action intentions when the risk was high than when the risk was low. The difference between the two was greater in the "base risk + chart" condition than in the "base risk" condition, demonstrating that the chart helped subjects respond appropriately to the level of risk. But even with the bare data provided in the "base risk" condition, a 40-in-1,000 risk yielded higher threat perceptions and action intentions than a 1-in-100,000 risk.

The "alternate risk" treatment provided a more sensitive test of the same question. For the low-outrage, high-risk situation, a 10× increase in risk (from 40-in-1,000 to 400-in-1,000) yielded a significant increase in threat perceptions and action intentions. But for the high-outrage, low-risk situation, a 10× decrease in risk (from 1-in-100,000 to 1-in-1,000,000) did not significantly affect threat perceptions or action intentions. It is not unreasonable that people would respond more to the first difference than to the second. Though both differences are one order of magnitude, in absolute terms the first is by far the greater difference. Once a risk gets as low as 1-in-100,000, moreover, further declines may well be psychologically irrelevant or difficult to comprehend. Very little is known about the relationship between the level of risk and the impact of a change of constant proportion, but it seems logical that halving or doubling a large risk would yield more change in response than halving or doubling a tiny one. (However, results from the "compare to normal" treatment suggest that expressing differences in terms of risk ratios may lead people to respond as much to a change from 1-in-1,000,000 to 1-in-100,000 as to a change from 1-in-1,000 to 1-in-100.)

Another possible explanation for these findings might be that high outrage reduces people's response to changes in risk magnitude. The "alternate risk" treatment was not used for the low-outrage, low-risk situation, so it is impossible to assess this possibility.

Outrage Effects and Outrage Reduction

Subjects in the high-outrage situation ("nuclear waste") were of course much angrier than in the two low-outrage situations, and they were much more distrustful of the DEP spokesperson, Schmidt. It is noteworthy that they were not more distrustful of the neutral information source, Dr. Baxter. This suggests that the distrust that typically characterizes high-outrage risk controversies need not contaminate all actors; an independent expert who is not affiliated with the distrusted authorities can sometimes be trusted.

Not surprisingly, outrage affected threat perceptions and action intentions. That is, subjects in the high-outrage, low-risk situation reported much higher perceived threat and higher action intentions than subjects in the low-outrage, low-risk situation, although the actual risk was identical. In addition, anger was highly correlated with threat perceptions and action intentions, as was distrust of the DEP spokesman for subjects in the high-outrage conditions.

When subjects received only risk numbers, the outrage effect was just as large as the 4,000-fold difference in risk between the high-risk and low-risk conditions. In other words, there were no significant differences in threat perceptions or action intentions between the "base risk" treatments for the radon story (at a risk of 40-in-1,000) and the nuclear waste story (at a risk of 1-in-100,000). When communication was improved by comparisons to normal background levels or by the risk chart, however, the outrage effect, though still substantial, was smaller than the 4,000-fold difference in risk.

Most encouraging is the apparent ability of some kinds of risk information to reduce threat perceptions and action intentions even in the presence of high outrage. Both comparisons to normal background and the risk chart had this effect for subjects exposed to the "nuclear waste" scenario. Many practitioners have suggested that when people are outraged, explanations of the risk data are unlikely to prove fruitful. In the study reported here, outrage certainly increased threat perceptions and action intentions – but outrage did not diminish the ability of comparisons to background and risk charts to reduce threat perceptions and action intentions.

And if anger is a measure of outrage itself, then both comparisons to background and risk charts actually influence outrage. Both treatments reduced anger for subjects who read the high-outrage, low-risk "nuclear waste" story.

Much more work needs to be done on the relationship between outrage and risk perception, but two conclusions are apparent from this study. First, outrage significantly affects risk perception. Second, well-handled explanations of risk magnitude from a trusted source significantly affect risk perception even when outrage is high, and may significantly affect outrage itself. When people are angry and upset about a high-outrage, low-risk situation, it may be that explanations coming from the distrusted source of the trouble do not help much. Merely providing risk probability data also does not appear to help much, even if the source is trusted. But considerable reductions in threat perceptions and action intentions are possible when a trusted, neutral source offers a comparison to background or a chart with a risk ladder, risk comparisons, and an action standard.

REFERENCES

Covello, V.T., P.M. Sandman, and P. Slovic, *Risk Communication, Risk Statistics, and Risk Comparisons* (Washington, DC: Chemical Manufacturers Association, 1988).

Covello, V.T., and F.W. Allen, "Seven Cardinal Rules of Risk Communication" (pamphlet), U.S. Environmental Protection Agency, Washington DC, April 1988.

Hance, B.J., C. Chess, and P.M. Sandman, *Improving Dialogue with Communities: A Risk Communication Manual for Government* (Trenton, NJ: Division of Science and Research, New Jersey Department of Environmental Protection, 1988).

Hance, B.J., C. Chess, and P.M. Sandman, *Industry Risk Communication Manual* (Boca Raton, FL: CRC Press/Lewis Publishers, 1990).

Ibrekk, H., and M.G. Morgan, "Graphical Communication of Uncertain Quantities to Nontechnical People," *Risk Analysis*, 1987, pp. 519-529.

Kaplan, R.M., B. Hammel, and L.E. Schimmel, "Patient Information Processing and the Decision to Accept Treatment," *Journal of Social Behavior and Personality*, *1*, 113-120, 1985.

Kasperson, R.E., "Six Propositions on Public Participation and Their Relevance for Risk Communication," *Risk Analysis*, 1986, pp. 275-281.

Krimsky, S., and A. Plough, *Environmental Hazards: Communicating Risks as a Social Process* (Dover, MA: Auburn House, 1988).

Sandman, P.M., "Risk Communication: Facing Public Outrage," *EPA Journal*, November 1987, pp. 21-22.

Sandman, P.M., "Risk = Hazard + Outrage: A Formula for Effective Risk Communication" (videotape) (Fairfax, VA: American Industrial Hygiene Association, 1991).

Sandman, P.M., *Responding to Community Outrage: Strategies for Effective Risk Communication* (Fairfax, VA: American Industrial Hygiene Association, 1993).

Sandman, P.M., P.M. Miller, B.B. Johnson, and N.D. Weinstein, "Agency Communication, Community Outrage, and Perception of Risk: Three Simulation Experiments," *Risk Analysis, 13* (6), 1993, pp. 589-602.

Sandman, P.M., N.D. Weinstein, and M.L. Klotz, "Public Response to the Risk from Geological Radon," *Journal of Communication*, Summer 1987, pp. 93-108.

Slovic, P., "Perception of Risk," *Science*, April 17, 1987, pp. 280-285.

Slovic, P., B Fischhoff, and S. Lichtenstein, "Facts Versus Fears: Understanding Perceived Risk," in D. Kahneman, P. Slovic, and A. Tversky (eds.), *Judgment Under Uncertainty: Heuristics and Biases* (Cambridge: Cambridge University Press, 1982), pp. 463-489.

U.S. Environmental Protection Agency, *Unfinished Business: A Comparative Assessment of Environmental Problems* (Washington, DC: U.S. Environmental Protection Agency, February 1987).

U.S. Environmental Protection Agency, *Reducing Risk* (Washington, DC: U.S. Environmental Protection Agency, 1990).

Weinstein, N.D., and P.M. Sandman, *Evaluating Risk Comparisons for Use in the Citizen's Guide to Radon* (Washington, DC: Office of Policy, Planning and Evaluation and Office of Radiation Programs, U.S. Environmental Protection Agency, November 1991).

Testing a Visual Display for Explaining Small Probabilities

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Running head: "Visual Display"

Appendix A

Paper Describing Pilot Work on Graphic Displays:

Testing a Visual Display for Explaining Small Probabilities

Testing a Visual Display to Explain Small Probabilities

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Abstract

Two experiments investigated the report of Kaplan _et al._[(1)] that a grid of dots representing the denominator of a small probability helped subjects understand that the risk was small. Study One compared perceptions of several probabilities (1/50, 200/10,000 and 1/10,000) and several formats (no dots, dots for probabilitiy denominator, and dots and X's representing the denominator and numerator, respectively) in the context of two hypothetical health risk decision problems. Study Two more precisely replicated the original Kaplan _et al._ experiment. Neither study found any significant effect of the visual displays on action intentions, and only small effects on perceived threat were observed.

Key Words: Risk communication; risk perception; visual display; graphics; risk probability

1. INTRODUCTION

Statements made by government officials and industry representatives often imply that the fundamental cause of disagreements over risk issues is the public's failure to understand the sizes of the risks in question. Overestimation of low-probability risks is viewed as the reason for excessive concern; failure to appreciate high-probability risks is seen as an important reason why people fail to take recommended precautions. Although responses to risks are certainly much more complicated than is suggested by such an analysis — and agreement that a risk is small is not the same as saying the risk is acceptable — there is nonetheless a need for ways of communicating better with the public about the sizes of risks.

Among the avenues that have been examined for helping people appreciate risk magnitudes are comparisons with more familiar risks[2-4] and choosing verbal labels to designate probabilities of different sizes.[5,6] Weinstein, Sandman, and Roberts[7] and Weinstein, Sandman, and Miller[8] have studied a variety of format variables, including comparisons to smoking, action standards, evaluative labels for different exposure levels, and advice.

The efficacy of conveying risk magnitudes through visual displays has received very little empirical attention. Weinstein, Sandman, and Roberts[7] found no differences in effect between a histogram and a textual presentation of the same risk information. Weinstein, Sandman, and Miller[8,9] found that the location of an assigned level on a exposure "ladder" helped orient subjects to their risk; with the risk itself held constant, subjects perceived it to be higher when it appeared near the top of the ladder than when it appeared near the bottom.

One visual display sometimes used is a matrix of dots or other symbols to represent the likelihood of the risky event under discussion. For example, the U.S. Environmental Protection Agency's Citizen's Guide to Radon[10] used a grid containing outlines of heads, with some outlines replaced by a black square, to indicate the probability of cancer from exposure to different radon levels. The effectiveness of this particular display has not been evaluated.

The results of a study by Kaplan, Hammel, & Schimmel[1] suggest that such visual displays can help people understand small probabilities and can encourage them to take actions that are appropriate for the size of the risk. In their investigation, college students were asked to decide whether they would choose to be vaccinated against a life-threatening influenza epidemic. The vaccination was highly effective, but carried a small probability of undesirable, but non-fatal, side effects. In one condition the likelihood of side effects was the same as the likelihood of getting influenza and dying; in the other two conditions the likelihood of side effects was much smaller than the likelihood of dying. Subjects were more likely to choose vaccination if the probability of these side effects was accompanied by a display of dots (for a risk of 1 in 10,000, for example, subjects compared a page containing 1 dot with another page containing 10,000 dots). In other words, the display appeared to help subjects see that the likelihood of suffering side effects was sufficiently small to justify receiving the vaccine. Thus, the present studies were design to explore this promising risk communication technique.

2. STUDY ONE

Study One compared reactions to a numerical presentation of the odds with reactions to a grid of dots reflecting the demoniator of the odds ratio. Two risk levels were used, 1 in 50 and 1 in 10,000.

Another issue examined was the potential difference between a format displaying only the denominator of the odds ratio and one displaying both numerator and denominator. Lippman-Hand and Fraser,[11] in discussing responses to genetic counseling, have suggested that some clients focus on the denominator of the odds ratio. When the risk is 1 in 100, for example, clients are reassured by attending to the large number who do not suffer problems. But other clients focus on the numerator, and are frightened by the vivid image of that one person in a 100 who does suffer harm.

Study One addressed this issue by compainrg two types of visual displays: a) a grid of dots reflecting only the denominator of the odds; and b) X's added to indicate on this grid which specific individual(s) experienced harmful effects (as in the EPA radon brochures). To exaggerate this factor we added a third risk condition of 200 in 10,000 (equivalent to 1 in 50). We expected that a display showing 200 "victims" in a field of 10,000 dots would make the situation appear much more dangerous than a display that showed 10,000 dots and only mentioned the odds being 200 in 10,000, or a display that showed 50 dots and mentioned the odds being 1 in 50, or a display that showed one X out of 50 dots.

2.1 Design

The two different decision dilemmas, three odds ratios, and three formats were crossed in a 2 x 3 x 3 factorial design.

2.2 Subjects and Procedure

Subjects were college students at Rutgers University enrolled in one of four different large classes. The sample (N = 896) was 34.9% male. An experimenter visited each class and asked for assistance in a study of how people make decisions about environmental and health risks. Each student received a experimental booklet and responded to it in this group setting. Assignment to condition was random. Although participation was voluntary, it appeared that at least 90% of those present took part in the study.

2.3 Materials

Page one of the experimental booklet presented a decision dilemma, page two contained the visual representation of the risk (when used) and pages three and four constituted the assessment questionnaire.

Hazard dilemmas. Two different decision problems were used, with each student responding to one only. The Insecticide Contamination dilemma concerned a misapplication of a pesticide in a dormitory that posed a risk of minor but permanent nerve damage. "The damage, if it occurs, is mild, such as tingling or numbness on fingers or toes." The choice offered was: stay in the dormitory and accept the risk, or endure the inconvenience of moving out and eliminate the risk. Experts' estimates of the probability of nerve damage to students who remained in the dormitory were provided, either "1 in 10,000," "200 in 10,000," or "1 in 50."

The Influenza Vaccine dilemma concerned a severe strain of influenza that would soon spread to the area. If they contracted the disease, young adults were likely to experience two to three weeks in bed and might be unable to finish the semester. A vaccine was available that offered almost total protection, but it posed a risk of minor but permanent nerve damage. The nerve damage effects and the probability of nerve damage were described exactly as for the pesticide. Unlike the Kaplan et al.[1] study, no numerical value was given for the likelihood of contracting influenza.

Visual depiction of probability. Three formats were used. (1) Subjects receiving the Numbers formats received no visual aid. (2) Subjects receiving the Denominator formats saw a regular grid of dots, with the number of dots equal to the denominator of the risk probability they were considering (i.e., either 50 dots or 10,000 dots). The density of the dots was held constant, so the 50 dots occupied an area approximately 1/2 inch by 5/8 inches and the 10,000 dots occupied an area approximately 7 1/2 inches by 9 inches. Above the grid was an explanatory statement, such as the following: "To help you get a sense of what that number [e.g., 1 in 10,000] means, this page shows what 10,000 dots look like." (3) Subjects receiving the Numerator Plus Denominator formats saw a similar grid, except that some dots were replaced by X's to represent the numerator of the risk probability, i.e., the number of victims out of the full group.

Assessment instrument. Four questions were employed to assess perceived risk. These referred to: the perceived danger of deleterious effects from the vaccine/pesticide (1 = no danger, 6 = very serious danger); the likelihood of experiencing negative side effects from the vaccine/pesticide (1 = no chance, 7 = certain to happen); how concerned about side effects respondents would be if they chose to get the vaccine/stay in the dormitory

(1 = not at all concerned, 5 = extremely concerned); and how worried about side effects respondents would be if they chose to get the vaccine/stay in the dormitory (1 = not at all worried, 5 = extremely worried).

Four questions elicited action intentions. These referred to the subject's own decision about obtaining the vaccine/staying in the dormitory, the advice the subject would give to a friend, the advice to a friend if contracting the flu/moving from the dormitory would ruin the friend's semester, and the advice to a friend who planned a sports career that would be ruined by nerve damage (for all, 1 = definitely move out of the dormitory/not get the vaccine, 5 = definitely stay in the dormitory/get the vaccine). Note that subjects who wanted to escape the risk of nerve damage from pesticide exposure would tend to take action, i.e., move out of the dormitory. In contrast, sujbects who wanted to escape the risk of nerve damage from the vaccine would be led toward inaction, i.e., not get vaccinated.

The questionnaire also asked subjects to describe how well the risk from the vaccine/pesticide had been explained (1 = I have a very good understanding of the risk, 4 = I feel very uncertain about the risk).

2.4 Results

Answers to the four questions relating to perceptions of risk were added together to form a single scale of perceived threat (alpha = .76), and answers to the four questions relating to the action decision were added together to form a single measure of action intentions (alpha = .81). Group means are presented in Table 1.

These data were examined by a 2 (Dilemma) x 3 (Odds Ratio) x

3 (Format) analysis of variance. The tests of greatest interest are the Format main effects and the interactions of Format with Odds Ratio and Dilemma.

The Format main effect approached significance for the perceived threat of the pesticide/vaccine side effects, $F(2,862) = 2.91$, $p = .055$, but not for action intentions, $F(2,862) < 1$. Post-hoc tests on the threat variables indicated that no formats differed reliably ($p < .05$) from any others. Looking at the separate components of perceived threat revealed significant Format effects on perceived likelihood, $p < .01$, and concern, $p < .05$, but not on danger or worry, p's $> .3$.

There were no significant interactions with Format: Format x Odds Ratio, $F(4,862) = 1.56$, $p > .15$ for threat and $F(4,862) < 1$ for action; Format x Dilemma, $F(2,862) = 2.17$, $p = .11$ for threat and $F(2,862) < 1$ for action; and Format x Odds Ratio x Dilemma, threat and action F's < 1.

Not surprisingly, the analysis did reveal significant effects of Odds Ratio on perceived threat, $F(2,862) = 65.8$, $p < .001$ and action intentions, $F(2,862) = 35.5$, $p < .001$. Appropriately, subjects reacted more to odds of 1 in 50 or 200 in 10,000 than to odds of 1 in 10,000.

There were also significant Dilemma effects. The perceived threat from the pesticide exposure was greater than the perceived threat from the side effects of vaccination, $F(1,862) = 25.1$, $p < .001$. The difference in action intentions, however, was in the opposite direction. Subjects given the pesticide scenario were more inclined to stay in the dormitory and risk nerve damage (when the alternative was moving out) than those given the influenza scenario were inclined to get vaccinated and risk nerve damage (when the alternative was possibly getting influenza), $F(1,862) = 228$, $p < .001$. Neither of the Hazard x Odds Ratio effects was significant, $F(2,862) = 2.02$, $p = .13$ for threat and $F(2,862) = 1.2$, $p > .3$ for action.

Additional tests showed that subjects in the Denominator and Numerator Plus Denominator conditions felt they understood the size of the risk better than subjects in the Numbers condition, $F(2,891) = 5.4$, $p < .005$, but the differences were very small (means of 2.19, 2.02 and 1.98, for the Numbers, Denominator, and Numerator Plus Denominator conditions, respectively).

3. STUDY TWO

Several factors might explain our failure in Study One to find effects of the visual display of probabilities on behavioral intentions. First, we used a series of verbal categories to assess behavioral intentions, whereas Kaplan et al. asked for a single numerical response (the percentage likelihood of vaccination). Second, our decision dilemmas — even the one pitting influenza against the side effects of vaccination — were not identical to those used by Kaplan et al. In particular, we did not provide a numerical value for the likelihood of contracting influenza if no vaccination was obtained. Third, Kaplan et al. used a version of the dot matrix differing slightly from the one we tested: they gave subjects the risk numerator (a single dot) on one page to compare with the numerator in dots on another page. Fourth, it is possible that our subjects reviewed the experimental booklets less carefully than had subjects in the Kaplan et al. study.

Study Two was designed to eliminate these differences. Only one decision dilemma (vaccination) was used, with wording taken directly from that used by Kaplan et al. A new risk perception question was added to the assessment instrument, a replicate of the Kaplan et al. question asking for a numerical estimate of the likelihood of vaccination. A new format was added with the risk denominator on one page and the numerator on another. Finally, rather than administering the experiment to a large college class, subjects were approached one at a time, and a condition was added in which the research materials were administered one step at a time, to make certain that subjects spent enough time looking at the visual display of the odds.

3.1 Design

Only one decision dilemma and one level of risk were used. There were four format conditions.

3.2 Subjects

Subjects were college students at Rutgers University. The sample (N = 287) was 47.7% male.

3.3 Materials

Decision problem. All subjects received the same decision problem. They were asked to imagine that their doctor had told them about a serious flu epidemic that was approaching. Without vaccination they would have "one chance in twenty (1/20)" of contracting the disease. Furthermore, if they did contract the disease they would have "one chance in fifty (1/50)" of dying from it. "This means that without receiving the vaccine you now have one chance in a thousand (1/1,000) of dying as a result of this flu." If they decided to receive the vaccine there would be no chance of getting the flu. However, the vaccination carried the risk of a rare side effect, the Guillain-Barre Syndrome, producing partial paralysis of the head, face, neck, and upper body. The risk of experiencing the Guillain-Barre Syndrome was "one chance in ten thousand (1/10,000)."

Visual depiction of probability. Four formats were used. (1) Subjects receiving the Numbers format received nothing additional to help them comprehend the risk. (2) Subjects receiving the Denominator format were told that a representation was provided "to help you visualize the probability of being adversely affected by the vaccine. On the next sheet of paper there are 10,000 dots. When you think about 1 dot out of those 10,000 you will be able to see the chance you have of contracting Guillain-Barre Syndrome as a result of the vaccine." The dots were spread over a 7" x 9" area in a regular grid. (3) Subjects receiving the Denominator Plus One format (duplicating the format of Kaplan et al. received the page of dots plus a subsequent page with only one dot. Their instructions said, "When you compare those [10,000] dots to the single dot on the following page, you will be able to see the chance you have" of experiencing the side effects of the vaccine. (4) Subjects in the Controlled Presentation group received the same materials as those receiving the Denominator format, although the manner of presentation was different.

Assessment instrument. The first evaluation question duplicated that of Kaplan et al. Subjects were asked to estimate the probability that they would choose to obtain the vaccine on a scale of "0 to 100, with 0 meaning, 'I absolutely would not take the vaccine,' and with 100 meaning 'I am certain that I would take the vaccine.'" The four questions used to assess perceived risk, the four questions used to assess action intentions, and the question used to assess perceived understanding of the risk were the same as those used in Study One. One additional, open-ended question asked subjects to explain how they had made their decision about getting vaccinated.

3.4 Procedure

Individual subjects were approached in public places, such as cafeterias and lounges, and were asked to participate in a study of decision-making about risky situations. The cooperation rate was 94%.

Subjects were assigned randomly to format. Those in the Numbers, Denominator, and Denominator Plus One groups received the decision problem, visual representation of the risk probability (except in the Numbers group), and assessment questionnaire at the same time. In the Controlled Presentation group these three items were handed to subjects one at a time, as subjects indicated their readiness to proceed to the next step, in order to ensure that subjects spent time examining the grid before they began to answer the questionnaire.

3.5 Results

Experimental effects. As in Study One, the answers to the four questions relating to perceptions of the risk from receiving the vaccine were added together to form a single scale of perceived threat (alpha = .80) and the answers to the four questions relating to the decision to receive the vaccine were added together to form a measure of vaccination intentions (alpha = .86). The association between these two variables was only moderate, with higher perceived threat associated with less intention to be vaccinated, $r = -.39$, $p < .001$. Table 2 presents the group means for these variables, for the probability of action, and for the perceived understanding of the risk from the vaccine.

Analysis of variance calculations found no effect of format on the self-reported probability of vaccination, $F(3,267) = .28$, $p > .5$, on the vaccination intentions scale, $F(3,283) = .24$, $p > .5$, or on self-reported understanding of the risk, $F(3,279) = 1.37$, $p > .25$. (The number of cases in these analyses varies slightly depending on missing data.)

There was a significant format effect on perceived threat, $F(3,280) = 2.90$, $p < .04$. Post-hoc tests using Tukey's procedure showed significant differences only between the two extreme means, with perceived threat being higher in the Denominator Plus One group than in the Controlled Presentation group. Additional tests showed that the Controlled Presentation group had the lowest perceived risk on all four items from the threat scale. These between-format effects were appreciable for concern, $p = .07$, and worry, $p < .05$, but not for the perceived danger and likelihood of vaccination side effects, p's $> .15$. Note, that none of the three formats using dots was significantly different from the format using only numbers.

Reasons for decisions. In contrast to the discrepancies between the present findings and those reported by Kaplan et al., one interesting result appeared in both investigations: Subjects were surprisingly reluctant to choose vaccination. In Study Two, partial paralysis from vaccination certainly seems preferable to death from influenza, and the likelihood of paralysis was described as ten times smaller than the likelihood of dying from influenza. Consequently, vaccination seems to be the obvious choice. Nevertheless, the mean reported probability of vaccination was only 66%-70% across conditions.

To explore this outcome further, the explanations subjects had given for their decisions in the Study Two open-ended question were examined. Approximately equal numbers of questionnaires at each level of the 5-point, personal decision question (where choices ranged from "definitely would not get vaccinated" to "definitely would get vaccinated") were coded by two assistants (N = 206). Four coding categories used were: consequences of vaccination, consequences of influenza, likelihood of vaccination side effects, and likelihood of influenza. Each code also indicated whether the answer referred to low threat (e.g., likelihood is small, consequences are minor) or to high threat (likelihood is great, consequences are severe). Multiple codes for each answer were permitted.

About one-quarter ofthe subjects mentioned consequences (of influenza or side effects) only, about one-quarter mentioned likelihood (of influenza or side effects) only, about one-quarter mentioned both consequences and likelihood, and about one-quarter mentiond neither. The subjects alluding to likelihood clearly favored vaccination: 38.1% referred to the likelihood of influenza as large or the likelihood of vaccination side effects as small, whereas only 12.9% referred to the likelihood of influenza as small or the likelihood of vaccination side effects as large. In contrast, subjects mentioning consequences were nearly equally divided between those favoring vaccination (23.3% mentioning consequence of influenza as serious or consequences of vaccination side effects as minor) and those contrary to vaccination (21.4% mentioning consequences of influenza as minor or consequences of vaccination side effects as serious).

In other words, although the probabilities presented in the decision problem were seen by most subjects as favoring vaccination, the consequences were not seen as consistently favoring any particular decision (and, as mentioned earlier, only about half the subjects did mention probability issues).

We suspect that labeling the health threat as "flu" and mentioning symptoms associated with typical cases of influenza ("inflamation of the respiratory tract, fever, muscular pain, and irritation in the intestinal tract") made it difficult for subjects to see this as a potentially fatal illness, even though the decision problem explicitly stated that "your doctor" says that "if you do contract the flu, you have one chance in fifty of dying from it." Had the health threat been either unfamiliar or a disease entity considered life-threatening, we believe that subjects would have chosen vaccination with greater certainty.

It is also worth noting that the vaccination dilemma contrasted purposeful exposure to a risk (vaccination) with passive waiting and contrasted an unfamiliar threat (Guillain-Barre Syndrome) with a familiar alternative.

4. DISCUSSION

These investigations failed to replicate the results of Kaplan et al., even when we reproduced their study virtually intact. In neither of our two studies was any visual display significantly different from the numbers only group in either threat perception or action intentions. Because of the large samples used, the failure to detect format effects can not be attributed to inadequate statistical power in the experimental design. No plausible reason appears to explain the discrepancy between our results and theirs.

Visual displays can vary along many dimensions, and versions different from those examined here or employed in different ways than those utilized here may eventually prove to be quite helpful. Furthermore, it should be recognized that the effects of visual displays when probabilities are large may be quite different from effects when probabilties are small. Nevertheless, although aids to help people appreciate the magnitudes of risks are much needed, the present experiments do not support the idea that using a visual display of dots to represent a small probability helps people appreciate that the risk is small.

Table 1

Study One: Format Effects on Perceived Threat and Action Intentions

Odds Ratio	Format					
	Numbers		Denominator		Denominator Plus Numerator	
	Threat	Action	Threat	Action	Threat	Action
	Influenza Vaccination Dilemma					
1 in 50	14.9	14.3	14.0	14.4	14.8	14.1
200 in 10,000	15.6	14.4	14.8	14.1	14.1	14.0
1 in 10,000	13.3	13.0	12.3	12.6	11.6	12.3
	Pesticide Contamination Dilemma					
1 in 50	15.7	17.7	15.2	17.2	15.9	17.1
200 in 10,000	16.3	17.4	16.1	17.8	17.1	17.9
1 in 10,000	13.4	15.6	13.1	15.3	12.5	15.3

Note: Entries are group means. The number of subjects in each Dilemma x Format x Odds Ratio group ranged from 46 to 53.

Table 2

Study Two: Format Effects on Dependent Variables

Response variable	Format			
	Numbers (N = 73)	Denominator (N = 70)	Denominator Plus One (N = 76)	Controlled Presentation (N = 68)
Probability of being vaccinated	65.7 (29.4)	68.6 (27.6)	68.5 (28.1)	70.2 (30.0)
Perceived threat from side effects	12.3 (3.68)	12.2 (3.33)	12.8 (3.49)	11.1 (3.53)
Vaccination intentions	14.2 (4.00)	14.3 (3.76)	13.8 (4.15)	14.35 (4.27)
Understanding of risk from side effects	1.92 (.66)	1.90 (.70)	1.88 (.58)	1.72 (.60)

Note: Entries are group means, with standard deviations in parentheses.

FOOTNOTES

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REFERENCES

1. R.M. Kaplan, B. Hammel, and L.E. Schimmel, "Patient Information Processing and the Decision to Accept Treatment," Journal of Social Behavior and Personality, 1, 113-120 (1985).

2. National Research Council, Improving Risk Communication, Washington, D.C., National Academy Press, 1989.

3. E. Roth, E.G. Morgan, B. Fischhoff, L. Lave, A. Bostrom, "What Do We Know About Making Risk Comparisons?" Risk Analysis, 10, 375-387, 1990.

4. P. Slovic, N. Kraus, and V. Covello, "What Should We Know About Making Risk Comparisons?" Risk Analysis, 10, 389-392.

5. D.V. Budescu and T.S. Wallsten, "Consistency in Interpretation of Probabilistic Phrases," Organizational Behavior and Human Decision Processes, 36, 391-405, 1985.

6. H.J. Sutherland, G.A. Lockwood, D.L. Tritchler, F. Sem, L. Brooks, and J.E. Till, "Communicating Probabilistic Information to Cancer Patients: Is There 'Noise' on the Line," Social Science and Medicine, 32, 725-731, 1991.

7. N.D. Weinstein, P.M. Sandman, and N.E. Roberts, Communicating Effectively About Risk Magnitudes (EPA/230/08/89/064), Washington, D.C., U.S. Environmental Protection Agency, 1989.

8. N.D. Weinstein, P.M. Sandman, and P. Miller, Communicating Effectively About Risk Magnitudes, Phase Two (EPA/230/09/91/003), Washington, D.C., U.S. Environmental Protection Agency, 1991.

9. P.M. Sandman, N.D. Weinstein, and P. Miller, "High risk or low: How Location on a 'Risk Ladder' Affects Perceived Risk," Risk Analysis, (in press).

10. United States Environmental Protection Agency, A Citizen's Guide to Radon, Washington, D.C., Author, 1986.

11. A. Lippman-Hand and F.C. Fraser, "Genetic Counseling: Provision and Reception of Information," Americal Journal of Medical Genetics, 3, 113-117 (1979).

Appendix B

Cover Letter, Stories, and Treatments for All Conditions

THE STATE UNIVERSITY OF NEW JERSEY
RUTGERS
Cook College - Department of Human Ecology
P.O. Box 231 - New Brunswick - New Jersey 08903-0231
Voice: 908/932-9153 - FAX: 908/932-8887

Cover Letter
(all conditions)

July, 1993

Dear Homeowner:

Thank you for talking with us on the phone and for agreeing to take part in our project.

At Rutgers we are studying how to explain environmental risks to people so that they can make their own decisions about what to do. The next two pages are a newspaper article that tells about a possible radiation problem in some homes in the Washburn Circle section of Middletown. Try to imagine that the home you live in now is located in Washburn Circle and that the last page of this booklet--the radiation report from the Middletown University Health and Safety Program--tells how much radiation has been found in your home.

Please take what you learn from the newspaper article and the Health and Safety Program radiation report and tell us how you think you would feel in this situation and what you think you would do. There are no right or wrong answers; we want to learn about your opinions and your reactions.

All answers are confidential. The code number on the questionnaire is used only to show us which questionnnaires have been returned, so we don't call and remind people who have already mailed theirs back.

THANK YOU VERY MUCH FOR AGREEING TO HELP.

Sincerely,

Neil Weinstein, Professor
Peter Sandman, Professor
William Hallman, Assistant Professor

Radon Risk to Middletown Homes

MIDDLETOWN — Homeowners in the Washburn Circle section of Middletown will find out soon whether their homes are radioactive.

The source of the radioactivity is radon, a decay product of uranium that occurs naturally in rocks and soil.

According to the U.S. Environmental Protection Agency, radiation from radon is a serious problem in some parts of the country.

EPA recommends that every home in the U.S., except apartments above the second floor, should be tested for radon.

According to geologist Charles Schmidt of the State Department of Environmental Protection (DEP), Washburn Circle is built on a granite ledge. Granite sometimes contains uranium, the radioactive mineral that decays into radon.

But Schmidt said there was no reason to predict that high radon levels would be common in the Washburn Circle area.

"Granite is common all through the state," he said. "Some homes turn out to have a radon problem, and lots of homes don't, even if they're right next door. The only way to find out is to test."

The Discovery and the Reaction

Washburn Circle's tests are part of an ongoing efort by the Middletown University Health and Safety Program to examine all areas of the county for possible trouble spots.

When the Washburn Circle Neighborhood Association heard about the testing program, it volunteered to recruit homeowners to take part.

It is not known whether any Washburn Circle homeowners tested on their own before the current survey was started. If any did test, the results they obtained are also unknown. Testing in the neighborhood is believed to have been infrequent.

The kickoff for the survey was a public meeting at which DEP experts briefed neighborhood residents about radon.

After that, Dr. Susan Baxter, the Director of the University Health and Safety Program, installed radon monitoring devices in the principal living areas of all homeowners in Washburn Circle who wanted to participate in the program. About 170 families took part.

The cost of the testing, about $8,000, was paid by the DEP.

Baxter announced yesterday that the University's work is finished. Each homeowner will receive a written report next week, she explained. After that, a public meeting will be scheduled to answer questions from homeowners and the media.

She declined to comment in detail until after the individual reports are received by the homeowners.

But she did say yesterday that the level of radon, and therefore the level of risk, varied substantially from one home to the next.

That wasn't especially surprising to Harriet Mossman, chair of the Washburn Circle Neighborhood Association.

"We understand that radon has to be looked at one house at a time," Mossman said. "We don't expect to find any serious problems, but we want to be sure."

Mossman added that the neighborhood association is "very grateful to the DEP and the University for moving so quickly" to explain about radon and carry out the tests.

"We are confident that we can do what needs to be done if anyone in the neighborhood finds a radon problem. We are proud of our neighborhood," she said.

"There are no villains here," Mossman said, "just a possible natural problem and a neighborhood that knows how to solve it."

The Nature of the Risk

According to radiation experts, granite often contains traces of uranium and other radioactive minerals. The uranium in the granite under Washburn Circle's 200 homes slowly decays into radon.

Because radon is a gas, it rises through the rock and soil toward the surface. If it happens to rise under someone's home, it can enter the house.

The radon tends to accumulate inside the basement or crawl space, and can rise into other parts of the house as well. It can also pass through openings and cracks in concrete slabs, and enter houses without basements or crawl spaces. Especially if a house is well-insulated, the radiation can build up.

Radon is a colorless, odorless, and tasteless gas. It can be detected only with special equipment.

Just as uranium decays into radon, the radon gas continues to decay into particles of other radioactive substances, sometimes called "radon daughters."

When these radioactive particles are breathed by people in the house, the particles may lodge in the lungs, where they continue to give off radioactivity. This is especially likely to happen to smokers. The result, experts say, is an increased

risk of lung cancer, a disease considered virtually incurable and almost always fatal. According to the EPA, radon is the second biggest cause of lung cancer, after smoking

The amount of lung cancer risk depends mostly on three factors: how much radon comes into the home from the radioactive rock underneath, how long people are exposed; and whether the radiation accumulates inside the house or escapes to the outside, where it is quickly diluted to safe levels.

If the risk is high enough to worry about, experts say, it can be greatly reduced by making sure the radiation has an easier path around the house than into the house – a combination of sealing and ventilation.

INSTRUCTIONS

Please imagine that the house you are actually living in now is located in Washburn Circle, and that the University Health and Safety Program radiation report that appears on the next page of this booklet is the radiation reading for your house.

Read the radiation report and then answer the questions on the blue sheet. Feel free to refer back to the newspaper article and to the Health and Safety Program report as much as you like when answering the questions.

MIDDLETOWN UNIVERSITY HEALTH AND SAFETY PROGRAM HOME RADIATION REPORT

At the request of the Washburn Circle Neighborhood Association, and with your permission, the University Health and Safety Program has measured the level of breathable radioactivity in your home due to naturally occurring radon. The level of extra radiation in your principal living area from radon was found to be:

__8__ picocuries of radiation per liter of air.

To interpret this result, it may help you to know the health risk caused by being exposed to this amount of radiation. If 1,000 people lived for 70 years in homes with 8 picocuries of radiation per liter of air, about 40 of them would be expected to contract lung cancer as a result of this exposure. In other words, for every 1,000 people exposed to this level of radiation over a lifetime, 40 more of them, on average, would get lung cancer than if they were not exposed to the radiation.

1 RADON

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The Nature of the Risk

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The radon tends to accumulate inside the basement or crawl space, and can rise into other parts of the house as well. It can also pass through openings and cracks in concrete slabs, and enter houses without basements or crawl spaces. Especially if a house is well-insulated, the radiation can build up.

Radon is a colorless, odorless, and tasteless gas. It can be detected only with special equipment.

Just as uranium decays into radon, the radon gas continues to decay into particles of other radioactive substances, sometimes called "radon daughters."

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risk of lung cancer, a disease considered virtually incurable and almost always fatal. According to the EPA, radon is the second biggest cause of lung cancer, after smoking.

The amount of lung cancer risk depends mostly on three factors: how much radon comes into the home from the radioactive rock underneath; how long people are exposed; and whether the radiation accumulates inside the house or escapes to the outside, where it is quickly diluted to safe levels.

If the risk is high enough to worry about, experts say, it can be greatly reduced by making sure the radiation has an easier path around the house than into the house – a combination of sealing and ventilation.

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80 picocuries of radiation per liter of air.

To interpret this result, it may help you to know the health risk caused by being exposed to this amount of radiation. If 1,000 people lived for 70 years in homes with 80 picocuries of radiation per liter of air, about 400 of them would be expected to contract lung cancer as a result of this exposure. In other words, for every 1,000 people exposed to this level of radiation over a lifetime, 400 more of them, on average, would get lung cancer than if they were not exposed to the radiation.

2 RADON

Radon Risk to Middletown Homes

MIDDLETOWN – Homeowners in the Washburn Circle section of Middletown will find out soon whether their homes are radioactive.

The source of the radioactivity is radon, a decay product of uranium that occurs naturally in rocks and soil.

According to the U.S. Environmental Protection Agency, radiation from radon is a serious problem in some parts of the country.

EPA recommends that every home in the U.S., except apartments above the second floor, should be tested for radon.

According to geologist Charles Schmidt of the State Department of Environmental Protection (DEP), Washburn Circle is built on a granite ledge. Granite sometimes contains uranium, the radioactive mineral that decays into radon.

But Schmidt said there was no reason to predict that high radon levels would be common in the Washburn Circle area.

"Granite is common all through the state," he said. "Some homes turn out to have a radon problem, and lots of homes don't, even if they're right next door. The only way to find out is to test."

The Discovery and the Reaction

Washburn Circle's tests are part of an ongoing efort by the Middletown University Health and Safety Program to examine all areas of the county for possible trouble spots.

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To interpret this result, it may help you to know that the average outdoor background level of breathable radiation in the United States, from all sources, is approximately 0.4 picocuries of radiation per liter of air. The radiation exposure in your house from radon is thus 20 times greater than the average outdoor background level.

3 RADON

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The chart on the next page will help you interpret your level.

4 Radon

RADON LEVEL (pCi/L)	CANCER RISK If 1000 people were exposed to this level over a lifetime, it would cause...	ACTION ADVICE AND COMPARISONS TO OTHER HAZARDS
10.0	About 50 lung cancer deaths	25 times average outdoor radon level
9.0	About 45 lung cancer deaths	The risk of dying from a stroke
8.0	About 40 lung cancer deaths	
7.0	About 35 lung cancer deaths	
6.0	About 30 lung cancer deaths	15 times average outdoor radon level
5.0	About 25 lung cancer deaths	
4.0	About 20 lung cancer deaths	**At 4 pCi/L EPA recommends that you reduce your home radon level**
3.0	About 15 lung cancer deaths	The risk of dying from colon/rectal cancer
2.0	About 10 lung cancer deaths	The risk of dying from diabetes
1.0	About 5 lung cancer deaths	
0.0	About 0 lung cancer deaths	Average outdoor radon level

Nuclear Waste Contaminates Middletown Homes

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The sand used in making the concrete had been taken improperly from a radioactive fuel storage site at a nuclear power plant more than a hundred miles away.

The DEP claims the level of radioactivity is "only a very small health risk," in the words of Charles Schmidt of the DEP's Bureau of Radiation Protection.

But DEP representatives and local residents clashed bitterly at a public meeting last December.

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The story begins in 1977, when the Wellspring Corporation, builder of the Washburn Circle Development, was hired by Downstate Electric Company to clear away contaminated sand from its Lincoln nuclear power plant, more than a hundred miles from Middletown.

The sand had been used to cover a storage site for spent nuclear fuel rods, and had absorbed some radioactivity.

Under state law, WellSpring should have disposed of the sand in a special radioactive waste site. WellSpring's payment from the utility company, just over $2 million, included money to cover the high fees charged for radioactive waste disposal.

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Saunders has declined to comment on the Washburn Circle problem, except for a one-sentence statement that "the radioactive contamination, if it happened, was entirely an accident."

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1 SAND

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Saunders has declined to comment on the Washburn Circle problem, except for a one-sentence statement that "the radioactive contamination, if it happened, was entirely an accident."

Legal investigations are continuing, but they probably won't do Washburn Circle homeowners much good. "Since the corporation responsible is bankrupt," explained Middletown City Attorney James Cavello, "there is no way to make it or Saunders pay unless criminal intention is proved."

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If the risk is high enough to worry about, experts say, it can usually be greatly reduced by making sure the radiation has an easier path to the outside — a combination of sealing and ventilation.

INSTRUCTIONS

Please imagine that the house you are actually living in now is located in Washburn Circle, and that the University Health and Safety Program radiation report that appears on the next page of this booklet is the radiation reading for your house.

Read the radiation report and then answer the questions on the blue sheet. Feel free to refer back to the newspaper article and to the Health and Safety Program report as much as you like when answering the questions.

MIDDLETOWN UNIVERSITY HEALTH AND SAFETY PROGRAM

HOME RADIATION REPORT

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<u>0.002</u> picocuries of radiation per liter of air.

To interpret this result, it may help you to know that the average outdoor background level of breathable radiation in the United States, from all sources, is approximately 0.4 picocuries of radiation per liter of air. The extra radiation exposure in your house from the radioactive sand is thus <u>two hundred times less</u> than the average outdoor background level.

3 SAND

Nuclear Waste Contaminates Middletown Homes

MIDDLETOWN — Homeowners in the Washburn Circle section of Middletown will find out soon just how radioactive their homes are.

The radiation measurements were carried out after the State Department of Environmental Protection (DEP) revealed last year that the concrete foundations and crawl space walls of homes in Washburn Circle contained nuclear waste.

The sand used in making the concrete had been taken improperly from a radioactive fuel storage site at a nuclear power plant more than a hundred miles away.

The DEP claims the level of radioactivity is "only a very small health risk," in the words of Charles Schmidt of the DEP's Bureau of Radiation Protection.

But DEP representatives and local residents clashed bitterly at a public meeting last December.

"We're not so sure the risk is small," said Harriet Mossman, chair of the Washburn Circle Neighborhood Association, which was organized in response to the contamination controversy.

"The numbers may turn out much higher than Mr. Schmidt is admitting," she said. "Of course he says there is nothing to worry about. Mr. Schmidt doesn't live in Washburn Circle."

The neighborhood association asked the Middletown University Health and Safety Program to carry out independent measurements. "We recognize that homeowners need a source of information they can trust," said Dr. Susan Baxter, Program Director. "That's why we agreed to help out."

Mossman thanked Baxter, commenting, "We didn't know where to turn for help and are pleased that the data will come from someone who has no axe to grind."

Baxter announced yesterday that the University's house-by-house radiation measurements are finished. Each homeowner will receive a written report within the week. After that, a public meeting will be scheduled to answer questions from homeowners and the media.

She declined to comment in detail on her findings until after the individual reports are received by the homeowners.

But she did say yesterday that the level of radiation, and therefore the level of risk, varied from one home to the next.

That wasn't especially reassuring to Harriet Mossman and the rest of the Washburn Circle Neighborhood Association.

"Whatever the numbers turn out to be," Mossman said, "Washburn Circle residents are angry, and we will stay angry until this contamination is removed and our health is protected."

She added that "for as much as 15 years we have let our kids play on radioactive front porches and have literally built our lives on radioactive foundations. Who knows what cancers lurk in our futures and our children's futures?"

The radioactive contamination was discovered last year by pure coincidence when a sixth grader was doing a science project on radiation. His borrowed geiger counter showed higher readings from his home's foundation walls than from the test samples provided by his teacher.

His parents persuaded the DEP to check out their son's findings, and the investigation was launched.

How A Neighborhood Was Contaminated

The story begins in 1977, when the Wellspring Corporation, builder of the Washburn Circle Development, was hired by Downstate Electric Company to clear away contaminated sand from its Lincoln nuclear power plant, more than a hundred miles from Middletown.

The sand had been used to cover a storage site for spent nuclear fuel rods, and had absorbed some radioactivity.

Under state law, WellSpring should have disposed of the sand in a special radioactive waste site. WellSpring's payment from the utility company, just over $2 million, included money to cover the high fees charged for radioactive waste disposal.

But instead of disposing of the radioactive sand properly, WellSpring used it to make concrete for the foundations and porches of the homes it was building in Washburn Circle. WellSpring declared bankruptcy in 1984.

According to legal records obtained by this newspaper, the president of WellSpring was Alexander Saunders.

Saunders has declined to comment on the Washburn Circle problem, except for a one-sentence statement that "the radioactive contamination, if it happened, was entirely an accident."

Legal investigations are continuing, but they probably won't do Washburn Circle homeowners much good. "Since the corporation responsible is bankrupt," explained Middletown City Attorney James Cavello, "there is no way to make it or Saunders pay unless criminal intention is proved."

The Nature of the Risk

According to experts, the radioactive contaminants in Washburn Circle foundations slowly decay into other radioactive substances.

These substances tend to accumulate inside the basement or crawl space, but can rise into other parts of the house as well. They can also pass through openings and cracks in concrete slabs, and enter houses without basements or crawl spaces. Especially if a house is well-insulated, the radiation can build up.

The radioactive gases and particles in the house are colorless, odorless, and tasteless. They can be detected only with special equipment.

When radioactive particles are breathed by people in the house, the particles may lodge in the lungs, where they continue to give off radioactivity. This is especially likely to happen to smokers. The result, experts say, is an increased risk of lung cancer, a disease considered virtually incurable and almost always fatal.

The amount of lung cancer risk depends mostly on three factors: how much radiation is in the contaminated foundations and walls; how long people are exposed; and whether the radiation concentrates inside the house or escapes to the outside, where it is quickly diluted to safe levels.

If the risk is high enough to worry about, experts say, it can usually be greatly reduced by making sure the radiation has an easier path to the outside — a combination of sealing and ventilation.

INSTRUCTIONS

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<u>0.002</u> picocuries of radiation per liter of air (pCi/L)

To interpret this result, it may help you to know the health risk caused by being exposed to this amount of radiation. If 100,000 people lived for 70 years in homes with 0.002 picocuries of radiation per liter of air, <u>one</u> of them would be expected to contract lung cancer as a result of this exposure. In other words, for every 100,000 people exposed to this level of radiation over a lifetime, one more of them, on average, would get lung cancer than if they were not exposed to the extra radiation.

The chart on the next page will help you interpret your level.

4 Sand

RADIATION LEVEL (pCi/L)	CANCER RISK If 1000 people were exposed to this level over a lifetime, it would cause...	ACTION ADVICE AND COMPARISONS TO OTHER HAZARDS
10.0	About 50 lung cancer deaths	25 times average outdoor radiation level
9.0	About 45 lung cancer deaths	The risk of dying from a stroke
8.0	About 40 lung cancer deaths	
7.0	About 35 lung cancer deaths	
6.0	About 30 lung cancer deaths	15 times average outdoor radiation level
5.0	About 25 lung cancer deaths	
4.0	About 20 lung cancer deaths	**At 4 pCi/L EPA recommends that you reduce your home radiation level**
3.0	About 15 lung cancer deaths	The risk of dying from colon/rectal cancer
2.0	About 10 lung cancer deaths	The risk of dying from diabetes
1.0	About 5 lung cancer deaths	Average outdoor radiation level
0.0	About 0 lung cancer deaths	

Radiation in Middletown Homes

MIDDLETOWN – Homeowners in the Washburn Circle section of Middletown will find out soon just how radioactive their homes are.

The source of the radioactivity is uranium, an element that occurs naturally in rocks and soil.

In this case, the uranium appears to be present in the concrete foundations and crawl space walls of homes in the Washburn Circle neighborhood.

According to geologist Charles Schmidt of the State Department of Environmental Protection (DEP), sand often contains small amounts of uranium. The sand used to make the concrete for Washburn Circle homes seems to be of that type.

"There is seldom enough uranium in the sand to cause any health problems, whether it's on the beach or used to make concrete," Schmidt said. "But it isn't rare to find uranium in sand."

The uranium was discovered last year by pure coincidence when a sixth grader was doing a science project on radiation. His borrowed geiger counter showed higher readings from his home's foundation walls than from the test samples provided by his teacher.

His parents persuaded the DEP to check out their son's finding, and the investigation was launched. The DEP later asked the Middletown University Health and Safety Program to conduct radiation tests throughout the neighborhood.

"Even though the chances are that it's only a very small health risk," Schmidt said, "the only way to know for sure is to test every home."

When the Washburn Circle Neighborhood Association heard about the testing program, it volunteered to recruit homeowners to take part.

The Testing Program

The kickoff for the survey was a public meeting at which DEP experts briefed neighborhood residents about radiation and uranium.

After that, Dr. Susan Baxter, the Director of the University Health and Safety Program, installed radiation monitoring devices in the principal living areas of all homeowners in Washburn Circle who wanted to participate in the program. About 170 families took part.

The total cost of the testing, about $8,000, was paid by the DEP.

Baxter announced yesterday that the University's work is finished. Each homeowner will receive a written report next week, she explained. After that, a public meeting will be scheduled to answer questions from homeowners and the media.

She declined to comment in detail until after the individual reports are received by the homeowners.

But she did say yesterday that the level of radiation, and therefore the level of risk, varied from one home to the next.

That wasn't especially surprising to Harriet Mossman, chair of the Washburn Circle Neighborhood Association.

"We understand that the measurements have to be looked at one house at a time," Mossman said. "We don't expect to find any serious problems, but we want to be sure."

Mossman added that the neighborhood association is "very grateful to the DEP and the University for moving so quickly" to explain the situation and carry out the tests.

"We are confident that we can do what needs to be done if anyone in the neighborhood finds a radiation problem. We are proud of our neighborhood," she said.

"There are no villains here," Mossman said, "It's just a fact of nature and we know how to deal with it."

The Nature of the Risk

According to experts, the uranium in the sand in Washburn Circle foundations slowly decays into other radioactive substances.

These substances tend to accumulate inside the basement or crawl space, but can rise into other parts of the house as well. They can also pass through openings and cracks in concrete slabs, and enter houses without basements or crawl spaces. Especially if a house is well-insulated, the radiation can build up.

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6 Sand

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1.0	About 5 lung cancer deaths	
0.0	About 0 lung cancer deaths	Average outdoor radiation level

Appendix C

Feedback Questionnaire

FEEDBACK QUESTIONNAIRE (all conditions)

How do you think you would react if you lived in Washburn Circle and found that you had this amount of radiation in your home? Feel free to refer back to the article and the University radiation report as you answer the following questions.

1. How clear was the newspaper article (Please circle the choice that best reflects your opinion):

   very clear — fairly clear — somewhat confusing — very confusing

2. How clear was the information about the seriousness of your radiation level provided by Middletown University Health and Safety Program:

   very clear — fairly clear — somewhat confusing — very confusing

3. How would you describe the danger from the radiation level found in your Washburn Circle home? (Please check the box that best reflects your opinion.)
   [ ] no danger
   [ ] very slight danger
   [ ] small danger
   [ ] moderate danger
   [ ] serious danger
   [ ] very serious danger

4. If you continued to live in your Washburn Circle home and did nothing about the radiation, what is your impression of the chance that the radiation would give you lung cancer?
   [ ] no chance
   [ ] very unlikely
   [ ] unlikely
   [ ] moderate chance
   [ ] likely
   [ ] very likely
   [ ] certain to happen

5. How angry would you feel to find this level of radiation?

   not at all angry — slightly angry — moderately angry — very angry — extremely angry

6. How concerned would you feel finding this level of radiation?

   not at all concerned — slightly concerned — moderately concerned — very concerned — extremely concerned

7. How frightened would you feel finding this level of radiation?

   not at all frightened — slightly frightened — moderately frightened — very frightened — extremely frightened

8. Given what you have learned about the risk, do you think it would be worth your spending $300 to reduce the risk to zero?
   [ ] definitely would spend $300
   [ ] probably would spend $300
   [ ] unsure what I would decide
   [ ] probably would not spend $300
   [ ] definitely would not spend $300

PLEASE TURN OVER

9. Given what you have learned about the risk, do you think it would be worth your spending $3,000 to reduce the risk to zero?
   [ ] definitely would spend $3,000
   [ ] probably would spend $3,000
   [ ] unsure what I would decide
   [ ] probably would not spend $3,000
   [ ] definitely would not spend $3,000

10. If you learned that it wasn't possible to reduce the radiation in your home, would that make you want to move away?
   [ ] would insist on moving away
   [ ] would feel a very strong desire to move away
   [ ] would feel a moderate desire to move away
   [ ] would feel only a little interest in moving away
   [ ] would not feel any interest in moving away

11. Imagine that you were looking for a new home in a new neighborhood, and found that it had this level of radiation (the level we told you was found in your home). Would this reduce your interest in buying this new home?
   [ ] definitely would not buy a home with this level of radiation
   [ ] would be very reluctant to buy a home with this level of radiation
   [ ] would be somewhat reluctant to buy a home with this level of radiation
   [ ] would be only a little reluctant to buy a home with this level of radiation
   [ ] would not be at all reluctant to buy a home with this level of radiation

12. From what you have read, do you think you could trust the risk information provided to you by Dr. Baxter of <u>the University Health and Safety Program</u>:

definitely could not trust	probably could not trust	uncertain	probably could trust	definitely could trust

13. From what you have read, do you feel that Charles Schmidt, <u>the State DEP spokesperson</u> quoted in the newspaper article, cares about the health and safety of your neighborhood:

doesn't care at all	cares very little	cares a little	cares a moderate amount	cares a lot

---

For classification purposes please tell us:

a. Your sex: [ ] male [ ] female

b. How much school have you completed?
   [ ] some elementary school
   [ ] finished elementary school
   [ ] some high school
   [ ] finished high school
   [ ] some college/finished 2-year college
   [ ] finished 4-year college
   [ ] some graduate study
   [ ] graduate degree

c. Yearly household income:
   [ ] $0-25,000 [ ] $25,001-50,000 [ ] $50,001-75,000 [ ] over $75,000

d. About how long did it take to read the booklet and fill out the questionnaire?
   [ ] 5 min. [ ] 10 min. [ ] 15 min. [ ] 20 min. [ ] 25 min. or more

THANK YOU. PLEASE RETURN THE QUESTIONNAIRE IN THE ENVELOPE PROVIDED.

BAND 2