RADON: RESIDENTIAL ATTITUDES TOWARD THE RISK

Rodney Fort, George Hinman, Robert Rosenman and Phil Wandschneider
Washington State University

Veradale, Washington (east of Spokane) is a region of high residential radon concentrations. Three hundred eighty residents of Veradale recently responded to a mail survey designed to elicit (1) their knowledge of and attitudes toward the risks of radon in their homes, (2) the actions they have taken or intend to take to identify and reduce those risks, and (3) policy preferences toward radon. Results reveal that these residents know that they live in an area with high radon levels, that radon causes lung cancer, and that radon will affect their health. However only 11% of respondents have had their homes tested for radon. This especially is puzzling because a large number of respondents claimed that (1) radon was important in home buying decisions, (2) they would test their own homes, (3) they would take action if such tests revealed problems, and (4) their willingness to pay for tests and improvements was well within the current costs of these actions. It remains a mystery why testing is at such a low level.

Three other results are of note. First, subsidies for radon tests and home improvements may be having the unintended consequences of unneeded improvements and (potentially) moves without improvements. Second, individuals want radon testing required and results made known during home purchase decisions. Third, at present, weatherization programs that concentrate radon are acceptable to individuals. Of course, the future may hold different results. Administrators of weatherization programs, who are trusted by respondents according to this survey, would do well to institute weatherization programs with reduced radon concentrations in mind.

INTRODUCTION

Radon in buildings has emerged as a major source of environmental concern because of the lung damage produced by its radioactive daughters. It is believed to produce as much radiation exposure to the general public as all other natural and man-made radioactive sources combined. It is now considered to be the second most important cause of lung cancer in the United States, exceeded only by smoking.

Weatherization often increases the concentration of radon in a building. Thus this energy conservation measure may have deleterious effects on human health. There are corrective measures that can be taken if people will adopt them. We undertook this project to survey the attitudes and behavior of residents living in an area known to have high levels of radon, but there also are implications for weatherization programs.

Veradale, Washington, a suburban area east of Spokane, has relatively high levels of radon. In the township containing Veradale, a Bonneville Power Administration (BPA) program recently measured radon concentrations in the living areas of 171 homes and found that the average reading was 9.37 pCi/l (picocuries per liter of air) and the highest reading 92.41 pCi/l (Bonneville Power Administration 1987). This average is more than twice the limit of four pCi/l, at which the

Environmental Protection Agency recommends that home owners take remedial action. We have used a mathematical model of radiation exposure recently developed at the University of Pittsburgh (Rogers et al. 1986) to conclude that a person living in a home with a concentration of 9.37 pCi/l on the first floor will receive a radiation dose of 24 rem/year to certain interior surfaces of the lung. This exposure subjects the person to increased risk of lung cancer. A model of the carcinogenic effect of radiation developed by the National Council on Radiation Protection (National Council on Radiation Protection 1984) predicts that a person living a lifetime in an average home in Veradale has one chance in sixty of developing lung cancer from radon exposure. In a home where the reading is 92.4 pCi/l the probability is one in six. Other models give similar or higher values (Ellett and Nelson 1985).

A mail survey of residents in Veradale, accomplished with the help of the Social and Economic Sciences Research Center (SESRC) at Washington State University, explored the knowledge, attitudes, and behavior of residents toward environmental threats, especially radon. Sets of related questions also examined sources of information, trust in these sources, and policy actions that citizens would support. The results provide insight into the social interactions between weatherization and indoor air quality.

The SESRC distributed a survey questionnaire to 700 residences, selected at random, in the mail zip code for Veradale. Each questionnaire was accompanied by a letter to the addressee explaining the purpose of the survey and encouraging a response. Non-respondents were requested twice again to respond, first through a postcard and then through a second letter containing a second copy of the questionnaire. A total of 384 questionnaires were returned. When account is taken of the number of questionnaires returned to sender and failures to answer because of death or illness, the cooperative response ratio was 61%. The questions were of the multiple choice type common in such surveys. Questions about transportation of radioactive waste, a subject which we wanted to compare with radon, are omitted from this paper to save space. The survey instrument is available from the authors on request.

Using cross-tabulations, or cross-tabs, additional information can be garnered by holding some individual characteristics constant. In particular, we can examine whether the ability to detect correct objective relative ratings of risky activities varies with how concerned or well-informed individuals consider themselves to be. In addition, given the manner in which individuals often misperceive objective risk, we looked at whether individuals take actions consistent with their levels of concern. Finally we were able to reveal whether individuals have policy beliefs consistent with their levels of concern about radon.

In what follows, the survey results are presented at three levels. First, some of the general responses concerning risk and the impact of information sources upon risk perceptions are presented. Second, using cross-tabs the relationships between how informed and concerned individuals consider themselves to be and whether tests for and amelioration of radon problems have occurred are examined. Finally, the implications of the survey responses for weatherization, in particular, and risk education and policy, in general, are offered.

GENERAL SUMMARY OF SURVEY RESPONSES ABOUT RISK

At the first level, survey responses are informative concerning the level of individual understanding about risk. The survey first asked respondents how well-informed they were about several environmental threats including radon in houses. Other issues for comparison were pesticides in food, possible production of weapons material at Hanford (Washington), transportation of radioactive wastes, a waste-to-energy burner in Spokane, and quality of drinking water. The responses were much the same for all issues. Most people indicated that they were somewhat informed but not well-informed.

Questions followed about the relative health risks of eight substances, technologies, and activities. The list included alcoholic beverages, commercial aviation, motor vehicles, nuclear power, pesticides in foods, radon in housing, surgery, and tobacco smoke. When asked about risks to society as a whole, residents rated alcoholic beverages, motor vehicles, and tobacco smoke highest; commercial aviation, radon in housing, and surgery lowest; and

nuclear power and pesticides in food as intermediate. As personal risks to themselves and their families, they rated motor vehicles highest; commercial aviation, surgery, nuclear power, and radon in houses lowest; and alcoholic beverages, pesticides in food, and tobacco smoke as intermediate. This comparative ranking of radon is consistent with other rankings of radon. For example, citizens queried about twenty-three environmental threats as part of Environment 2010, a project sponsored by the state of Washington to preserve the high environmental quality of the state, ranked radon among the lowest.

We found that Veradale residents have a reasonably accurate understanding of radon levels and their health importance. The majority knew that radon causes cancer and that the radon level in Veradale is higher than the national average. Remarkably, almost 40% placed the chance of acquiring lung cancer after twenty years in a home with radon concentration of four or five pCi/l in the right range (one in a hundred to one in a thousand).

Only 11% of the people answering the survey had had their homes tested for radon. Those who had not done so gave a variety of reasons. The most frequent reason was that the occupant just had not gotten around to it but intended to have it done. Other frequent choices were (1) not feeling a need to have it done, (2) not having the money to make changes if they were needed, (3) concern that the test results might tend to reduce the value of the home, and (4) lack of knowledge of testing services. More than half of the residents who did not have a radon test indicated that they would pay $10 to $50 to have the test. The overwhelming majority indicated that they would make improvements if the results of a test showed a level in excess of four to five pCi/l and would pay an average of $700 to reduce the level below this threshold.

Among the residences where radon levels were tested, the average value was six pCi/l, the lowest zero, and the highest sixteen pCi/l. Thus the levels were not as high as those in the more extensive BPA measuring program. Measurements were taken, at least in some homes, in more than one level of the residence with the highest reading being in the basement.

Half of the respondents who had their homes tested took some action to reduce radon levels. Remedial measures included keeping windows open, installing fans, sealing cracks and joints, and in three cases (out of 42) installing air-to-air heat exchangers. No one moved out of the house or called a realtor to put it up for sale.

Most respondents did not believe that the value of their homes had changed as a result of testing and other actions, but a small number estimated changes up to $10,000. Likewise most people did not believe that the tests and other actions affected the health of their families. Among the twenty people who answered a question about how much had been spent on improvements to reduce radon in their homes, twelve said nothing. The eight others spent from $20 to $1,000 with the average being $390. The same eight people also were asked how much more they would pay to have radon levels reduced below four pCi/l. The average amount was $1,065, the lowest zero, and the highest $5,000.

The final set of questions covered policy issues related to radon. Some of the results were surprising in view of the low ranking of radon as an environmental threat. Sixty percent of respondents indicated that knowing that the level of radon in a home exceeded four pCi/l would be a very important factor in their decision to buy the home, and 88% rated the knowledge very important or somewhat important. Two-thirds considered a requirement for a radon inspection at the time a house is sold as very or somewhat important and 91% indicated that if such a law were in place the results of the test should be made available to prospective buyers. Three quarters of the people considered it very or somewhat important for the state of Washington to establish a standard for the radon level in a home, above which radon is considered to be hazardous to an occupant.

About 60% of the respondents believed that operators of businesses open to the public should be subject to radon inspections and should be required to correct any excess radon levels found. In the area of public operations, 84% believed that schools should be inspected and that operators of schools, hospitals, and other public buildings should be required to reduce levels to a state standard.

Turning to the impact of information sources upon public perceptions, the survey explored the potential effectiveness of various media, organizations, and authorities to communicate with residents about environmental matters. Effective communication requires both the attention and trust of the intended receiver of information. Survey recipients responded to a question that asked about their information sources on environmental issues. The most frequent source was television, followed by radio and news magazines. Nature, environmental, and outdoor recreation magazines were seldom consulted for environmental information. Likewise, friends, family, and neighbors were seldom used.

Residents expressed the highest trust in the accuracy of environmental and news magazines, but television and radio also were considered accurate. Family, friends, and neighbors were not considered reliable by most respondents.

One survey question asked respondents how much they trusted each of twenty-two organizations and professional groups concerned with people and the environment. The results of this question are summarized in Table 1.

CONCERN AND THE LEVELS AT WHICH INDIVIDUALS ARE INFORMED

Cross-tabs were employed to untangle the relationship between reported informed levels and concern about radon in the home. As a preface, 20% of respondents considered themselves well-informed, 50% somewhat informed, 25% little informed, and 5% not informed about radon in housing. In addition, 5% of the very informed, 5% of the somewhat informed, 3% of the little informed, and none of the not informed considered radon to be the most likely risk they or members of

Table 1. Degree of Trust in Information Sources

Organizations	Professional Groups
Most Trust	*Most Trust*
Environmental Organizations	Medical Profession
U.S. Environmental Protection Agency	Federal Judiciary
	University Scientists
	Government Scientists
Intermediate Trust	*Intermediate Trust*
U.S. Department of Energy	Industry Scientists
Federal Emergency Management Agency	State Governor's Office
Local Government	
U.S. Congress	
State Legislature	
WA Dept. of Social and Health Services	
Bonneville Power Adminisrtation	
Waste Management Firms	
Public Utilities	
Food Production Firms	
Least Trust	*Least Trust*
U.S. Department of Defense	U.S. President and Administration
Chemical and Drug Companies	Legal Profession

their families would face among the list of eight every day risks mentioned previously and discussed below.

The veracity of individuals' responses about informed levels was examined in three cross-tabs with reported informed levels. First, their ratings of the risks of radon in housing relative to the other risks earlier mentioned were examined. In objective terms of annual fatalities, tobacco smoke and alcoholic beverages are worst, followed in order by motor vehicles, radon in housing, surgery, commercial aviation, and nuclear power. While we did not locate a relative ranking for pesticides in food, we believe that it would most likely be below radon in the home. Second, their ratings of community radon levels were compared to the national average levels for radon. Responses in the "somewhat higher than average" and "much higher than average" range reflect the true relationship. Third, their estimate of the probability of lung cancer if they lived in a home with five pCi/l radon concentration for twenty years was compared to the correct response of between one per hundred and one per thousand. The results are in Table 2.

The respondents systematically underrated the relative risk of death associated with radon in housing with about 80% of the estimates below actual levels for all informed levels. On the other hand the level of correct answers to the community radon level question increases with the informed level. Furthermore, we considered it rather amazing, given inability of populations to estimate risk, that about one-third of each informed level (up to nearly one-half for the somewhat informed) identified roughly the correct actuarial probability of lung cancer.

CONCERN AND ACTION: ANOMALIES AND COMMON SENSE

The next question concerns whether individuals take actions consistent with their level of concern over the effects of radon. Table 3 presents respondents' reported levels of concern about the health, physical property, and monetary effects of radon.

We used several cross-tabs to investigate these connections. Table 4 shows that the percentage of respondents for whom radon is important in a home purchase decision rises with general level of concern. Indeed all of the very concerned reported that radon was an important consideration in a home purchase.

Table 5 shows relationships between levels of concern about health and monetary effects of radon and actions taken (1) to test for the gas and (2) to reduce radon exposure after a test. There is somewhat of a trend toward more testing and subsequent action with increasing levels of concern.

We also examined three cross-tabs between the level of radon test results and whether or not subsequent action was taken. The three cases differed with respect to who paid for the test. The three possibilities were (1) the respondent, (2) BPA, or (3) other. Unfortunately, in the survey we did not ask who paid for any subsequent action after the test, which is the more important question. However we believe that if BPA paid for the test, they were at least partially subsidizing the corrective action if the level was high. We found that only about a third of the self payers with high (more than four pCi/l) radon levels took further action but that most of the respondents did when BPA paid for the test and the level was high. However we also found about the same ratios for further action in the cases where the radon level was not high. BPA participation in the test seemed to stimulate corrective action whether or not the radon level was high. However the statistics are weak because the numbers are small.

Table 6 shows the variety of actions that survey respondents said they would take if radon tests indicated a problem. Greater levels of concern result in greater levels of each type of action and less inclination to do nothing. Most people say that they would make improvements rather than move or improve and then move. However among the very concerned there is some tendency toward "radon flight." In view of the BPA effect on stimulating action after testing "radon flight" may be exacerbated by subsidized testing and improvements.

We asked people whether they were likely or not to test their next home for radon. Almost all those who had tested their present homes (93%) said it was likely that they would test the next one, and

Table 2. Rating the Risk from Radon in Housing

Informed Level	Correctly Rated Relative Radon Risk	Correctly Rated Community Radon Levels	Correctly Identified Lung Cancer Probability
Very	11%	68%	34%
Somewhat	11%	64%	45%
Little	11%	44%	33%
Not	6%	17%	28%

Table 3. Concern about Health, Property, and Monetary Effects

Concern Level	Health	Property	Monetary
Not	11%	32%	15%
2	10%	22%	15%
3	13%	14%	13%
4	21%	13%	18%
5	19%	7%	16%
Very	25%	11%	23%

Table 4. Importance of Radon in Home Purchase

Concern Level	Health Effects Radon Important	Monetary Effects Radon Important
Not	44%	59%
2	70%	83%
3	91%	83%
4	83%	92%
5	98%	95%
Very	100%	100%

Table 5. General Responses Across Levels of Concern

Concern Level	Health Effects		Monetary Effects	
	Tested	Took Action	Tested	Took Action
Not	2%	0%	9%	0%
2	19%	29%	13%	57%
3	6%	67%	16%	50%
4	12%	44%	13%	56%
5	15%	44%	7%	75%
Very	12%	70%	11%	44%

Table 6. Types of Actions Across Levels of Concern

Concern Level	Health Effects None	Improve	Move	Improve and Move	Monetary Effects None	Improve	Move	Improve and Move
Not	35%	58%	5%	2%	27%	65%	6%	2%
2	19%	74%	4%	4%	13%	79%	4%	4%
3	13%	76%	7%	4%	10%	77%	10%	3%
4	5%	88%	3%	5%	2%	88%	7%	4%
5	0%	90%	7%	3%	6%	87%	4%	4%
Very	2%	75%	12%	10%	3%	75%	10%	12%

75% of those who had not tested their present homes said that they were likely to test the next one.

Table 7 shows how much people are willing to pay for radon tests. Those most concerned about health and monetary effects of radon are willing to pay more, but very few people will pay more than $100. We do not know whether this limit represents the actual marginal value that individuals place on reducing their uncertainty about the presence of radon in their homes or their knowledge about the current price of radon tests.

CONCLUSIONS: IMPLICATIONS FOR EDUCATION AND POLICY

Individuals appear quite well-informed about radon, despite answering that they were informed but not well-informed. While they underrate the relative risk of radon, there is a high level of understanding about both the absolute lung cancer dangers and the level of radon concentrations in their community. They also understand that physical effects on property are nonexistent.

In addition, typically their observed actions and their "what if" responses are consistent with the level of concern, but there remain two interesting anomalies. The first is the low level of radon testing that has been undertaken. It is true that those more concerned with health and monetary effects tested more often, but the level of testing was only 11% of the sample. The second anomaly is that, in percentage terms (important because this is derived from actual observed actions of about thirty respondents), those very concerned about health and monetary effects of radon test at a very low rate and are mixed in whether or not they actually took action in the presence of the test results. This "mixed bag" phenomenon also holds true of the type of actions that respondents said they would take, including no action, make improvements, move, and improve then move. This especially is interesting because very high percentages of respondents, both those who have tested and those who have not, both those who are concerned about health and monetary effects and those who are not, claim that they will test their next house.

Given the low level of testing (11% of the sample), the following conclusion should be viewed cautiously, but it appears that subsidized testing programs by BPA may have unintended consequences. First, there is a higher propensity to take actions based on tests indicating low radon levels among those who have their tests paid for by BPA. In addition, taking respondents at their word, tests are more likely to drive the very concerned from their houses, relative to other levels of concern, with no improvements made.

Concerning education, there appears to be room for it. Individuals are fairly well-informed about the absolute risks associated with living in the presence of high radon levels. However, like others questioned about radon, respondents have understated the relative risks of radon. Generally, then, education would prove useful to individuals in their role as decision makers in the presence of a variety of risky elements. On the other hand education about the particular risks associated with radon would not be useful because individuals already appear to be quite well-informed about them. Television and radio programs would get them where they listen and in a way they find reliable. For concerted

Table 7. Willingness to Pay for Radon Tests

Concern Level	Health Effects			Monetary Effects		
	$0-50	$51-100	$101-up	$0-50	$51-100	$101-up
Not	77%	20%	3%	75%	22%	2%
2	52%	48%	0%	42%	58%	0%
3	51%	49%	0%	26%	69%	3%
4	32%	64%	2%	38%	60%	0%
5	21%	77%	0%	26%	74%	0%
Very	24%	74%	05	25%	73%	0%

efforts, Table 1 serves as a guide to which groups and organizations the respondents found trustworthy. In short, U.S. Environmental Protection Agency personnel and university scientists on television and radio would be most effective. In addition, in the sense of having the highest marginal impact, it is interesting to note that limited knowledge about relative risks of radon is not restricted to those considering themselves least informed. Educational efforts should not be aimed simply at those who consider themselves poorly informed.

On the policy front, evidence on inspection, information provision, and willingness to pay for both testing and improvements are inciteful. People want the information when they are buying houses. They want inspections and, given such inspections, they want the information made available. Another policy issue is uncovered from responses about whether a radon test should be required by law at the time a home is sold. At all levels of concern, except the most unconcerned, a majority of respondents felt that there should be radon legislation. The size of the majority increases with the level of concern until nearly 90% of the very concerned claim that they would support such legislation.

Given the result that weatherization can contribute to the concentration of radon, what can be learned from this survey about fixing the problem so that weatherization can be achieved? The answer is straightforward. Although radon concentrations pose health problems, they do not appear to pose any problem for public acceptance of weatherization programs. The reason is that people are responding to the health risks associated with radon at very low rates. With response at low rates, currently there appears to be no resistance to weatherization based on radon concerns.

The obvious caveat is that this statement concerns the current situation. Should response rates increase, a reevaluation would be in order. In addition, given the past history of litigation concerning known health risks, there is something to be said for taking current action even though there is no current public resistance to weatherization programs based on radon. In as much as BPA is an organization that our survey respondents consider moderately trustworthy, perhaps the best advice to BPA concerning weatherization is the following: Try to sell a weatherization program complete with radon testing and remedies. The public will believe it.

There does remain one overriding anomaly. From willingness to pay for testing, where most are willing to pay (and higher amounts by the concerned), but almost nobody above $100, the price of testing does not seem to be an impediment to testing. In addition, given the actual improvements that were undertaken and stated willingness to pay for such improvements, the price of improvements does not seem to be an issue. Nevertheless only 11% of sample respondents had a radon test. It remains a mystery just why responses generally indicate a willingness both to pay and to take action, but testing and improvements remain at low levels. Perhaps the answer is that, while individuals understand the absolute levels of radon in their community and the associated lung cancer risks, their relative rating of radon as a risky element puts it very low on their risk priority list. Another

possibility is that individuals are exhibiting the very human characteristic of denial. By ignoring radon, that is, not testing their homes, the immediacy of the problem is artificially removed. Still other possibilities are that respondents are less than truthful or that they do not trust the accuracy of the tests or that their willingness to pay does not reflect the value they put on tests but rather their knowledge of current radon test prices.

ACKNOWLEDGMENTS

The authors wish to acknowledge the participation of William Budd, Eugene Rosa, and James Short in the preparation of the survey questionnaire.

REFERENCES

Bonneville Power Administration. 1987. *Radon Monitoring Results from BPA's Residential Weatherization Program*. Portland, Oregon.

Ellett, W. H., and N. S. Nelson. 1985. "Epidemiology and Risk Assessment: Testing Models for Radon-Induced Lung Cancer." In Gammage, R. B., and S. V. Kaye (eds.) *Indoor Air and Human Health*, pp. 79-107. Lewis Publishers, Chelsea, Michigan.

National Council on Radiation Protection and Measurement. 1984. *Evaluation of Occupational and Environmental Exposures to Radon and Recommendations*, NCRP 78. Bethesda, Maryland.

Rogers, G. O., N. P. Hummon, and D. J. Strom. 1986. "A Preliminary Model of Radon Exposure." Paper presented at the Society for Risk Analysis Annual Meeting, November, 1986. Boston, Massachusetts.