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RADON RISKS: ATTITUDES, PERCEPTIONS AND ACTIONS

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Preface

Indoor radon constitutes a major health risk. As many as 8 million homes in the USA may have elevated radon levels with accompanying lung cancer risks several orders of magnitude above many other environmental hazards. Still, less than 5 percent of all homes have been tested for radon and interest in the topic seems to be tapering off, after a rise following the widely publicized discovery of extreme radon levels in some homes in early 1985.

The U.S. Environmental Protection Agency has sponsored a program of research on radon risk communication aimed at finding effective methods for informing people about radon risks and encouraging them to monitor their homes and mitigate if high radon levels are found. State level agencies also have sponsored research on this topic. Several studies have now been completed. Others, while still not finished, have produced some significant interim results. This report summarizes this research, discusses it critically and suggests conclusions relevant to radon policy as well as topics for further research. Some studies performed in Sweden also have been treated.

I have written this report mostly from the perspective of a psychologist, and I have attempted to relate some of the radon risk communication research to general discussions of attitude change and attitude measurement. Some practical implications are summarized in the appendix.

Ann Fisher and Reed Johnson have given very valuable and detailed comments on the manuscript. Amos Tversky made several stimulating remarks.

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1. Executive summary

1.1. Introduction

Indoor radon constitutes a major health risk. As many as 8 million homes in the USA may have elevated radon levels with accompanying cancer risks several orders of magnitude above most other environmental hazards. Nevertheless, less than 5 percent of all homes have been tested for radon. Radon in private homes remains the responsibility of the home owners and there is no legislation that compels people to reduce this particular risk.

The U.S. Environmental Protection Agency has sponsored a program of research aimed at finding effective methods for informing people about radon risks and encouraging them to monitor their homes and mitigate if high radon levels are found. State agencies also have sponsored research on this topic. This report summarizes the research, discusses it critically and suggests conclusions as well as topics for further research.

Some studies performed in Sweden are included because of interesting differences between that country and the USA in reactions to radon risk. Also, radon has been an issue longer in Sweden than in the USA, especially radon emitted from building material.

1.2. The media and radon risk

Radon was not widely discussed as a health risk in the USA before 1985. That year national attention was given to a very dramatic case in the home of a Pennsylvania resident. The radon level was much beyond what had previously been believed to be possible from geological radon in a home. Subsequent screening has shown that there is definitely a radon problem in many homes, although very few have had levels as high as the initial Pennsylvania case. Radon was highly salient in the media in 1985 but according to some authors interest is now tapering off (see Figure 1, page 17).

1.3. Properties of radon risk

Radon is a risk with certain unique properties. It shares some of the characteristics of all risks from ionizing radiation (slow effects in the form of cancer, a risk from a physical agent that cannot be sensed). At the same time it is a risk that people are exposed to in their homes. Homes are usually perceived as safe places under one's own control and responsibility. It is not obvious that some person or organization is to be blamed for radon risks, in contrast to such risks as nuclear power plants.

1.4. Radon risk compared to life style risks

Radon risk has been compared to such life-style risks as smoking or drinking alcohol. The similarity is that people take these risks as private individuals. Society is reluctant to legislate the risk level to which they can expose themselves. They must act voluntarily to mitigate or eliminate these risks.

There are also differences between radon and life-style risks. First, radon exposure does not confer any benefit as smoking and alcohol do. Second, it is not clear who, if anyone, is responsible for radon risk. Radon risks were largely unknown to the US public before 1985 and most home owners bought their current houses before then.

Reducing a life-style risk involves making a commitment to action in spite of temptations to delay action. In this sense, there is a similarity between radon and life-style risks. Many people in one of the studies reviewed here became "procrastinators", i.e. they changed from indifference towards the risk to acknowledging the necessity of action "in principle". It is well known that people find it very difficult to quit a risky habit and that rationalized delays are very common. It is too early to tell if the same phenomenon will occur for radon risk but it [redacted] possible. On the other hand, testing for radon and mitigati[redacted] require only two discrete actions while the ex-smoker has to resis[redacted] cigarettes several times a day. People do not have to quit a habit (or develop a new one) in order to test and mitigate for radon.

1.5. Studies of risk attitudes and risk perception

There have been several studies of how people perceive and respond to radon risk. Initially it was believed that information about radon risk might give rise to panic reactions, but experience has not confirmed this concern. On the contrary, people are often quite indifferent to the issue, at least in regard to their own homes. This indifference can be interpreted as a manifestation of a rather general tendency to deny health risks. It has been suggested that denial of radon risk is moderately strong compared to other kinds of denial.

Many people are outright negative to radon testing. Pennsylvania authorities at one point went from door to door and offered free radon testing. Still, about 50 percent refused to have their homes monitored. Some of them may have been concerned that rumors of a radon problem would affect property values in an area.

It is worth stressing that people tend to be indifferent t[redacted] radon risk in spite of the fact that the EPA action level is quit[redacted] high compared to other risks. The actual risk level seems to be a

poor predictor of public response to risk. The action level in Sweden is presently 2.5 times higher than the US level corresponding to the lung cancer risk of smoking a pack of cigarettes per day. Still, Swedes are as indifferent to radon risk as Americans.

As might be expected on the basis of these facts, there is usually only a weak correlation between the scientifically estimated risk level, as physically measured, and the level of perceived risk. Some people with low levels of radon in their homes are quite concerned while others, with quite high levels, are indifferent. This low correlation may partly arise from the fact that the physical measurements are not perfect indicators of the actual risk level. The risk also depends on how much time people spend in the house, their age and other factors. Still it is reasonable to conclude that there is a weak correlation between perceived and actual radon risk. There is little evidence suggesting that people do not believe that the radon readings are accurate or that the risk assessments are incorrect. They probably believe that the risk is there, in principle and for people in general, but that they themselves are for various reasons less vulnerable, more lucky or they just do not care about getting involved in protecting themselves against another risk, they just take it.

However, the effects of information about radon risk provide a partly different picture. Two studies have shown that people revise their risk estimates in the "right" direction, i.e. in the direction suggested by the readings of radon levels in their homes. Still, other data suggest that even for risk revisions there may be irrational denial factors at work. There is some support for the thesis that people are more inclined to accept that <u>other</u> people's homes in their community may be at risk than that <u>their own</u> homes may be at risk.

If actual risk is not strongly correlated with perceived risk, then what accounts for perceived risk? There are some correlations with background data. Older people are less worried about radon, and parents of small children more so. In some studies women have been shown to be more worried than men, but the gender difference is much smaller for radon risk than for many other types of risk. People with a family member with cancer were more concerned about radon in one study. Some personality variables have been suggested as predictors of perceived radon risk but so far little research has been carried out on this issue.

These factors are only weakly related to perceived radon risk. There is simply not enough research available to support more definite statements about what factors influence perceived radon risk.

I suggest that radon risk perception is a special case of eg[redacted] related risk, i.e. it is a risk that is closely related to se[redacted] conceptions. This hypothesis is derived from evidence that peopl[redacted] tend to perceive their homes as extended parts of their selves, especially if they have lived in them for a long time. And there is a tendency to deny that something as closely related to oneself as one's home (or body) could be threatening.

Data indicate that people with a longer history of living in a house are more likely to deny radon risk. Other supporting data show that people react strongly to radon risk when it is imposed on their neighborhood - not on their homes. Part of this reaction is probably a result of moral indignation over being exposed to a risk by someone. People strongly resent a loss of control, and they tend to perceive that which they can control and are responsible for as benign.

Communication about radon risk with the general public has been studied in two major investigations, one of which was especially concerned with mitigation. These studies also investigated the effects of a major attempt by a television channel in the Washington, D.C., area to encourage people to buy test kits, available at reduced price in grocery stores. Over 100,000 kits were quickly sold and demand was by no means exhausted. About 6 percent of the home owners in the area bought test kits. However, only about half of those who bought the kits turned them in f[redacted] analysis and few people who had elevated radon levels in the[redacted] homes reported any effective mitigation beyond such behavioral measures as keeping windows open more often.

The EPA-sponsored outreach activities in a Maryland community were probably more effective than the simultaneous television campaign in stimulating people to test for radon. The proportion that tested their homes rose from about 5 to 15 percent. There is some evidence that the television campaign was effective in making people aware of radon risk, but less effective in stimulating them to act. A similar finding was reported in a New Jersey study of smaller scope where it was found that there is a link between risk perception and action but that the link was quite weak. The weak effects of the television campaign are in line with extensive experience from other studies of health-related public service messages. The effects are usually quite marginal. In addition, people tend to distrust television.

A few studies have investigated knowledge about radon and found that people are fairly well aware of its general properties, although they lack specific knowledge. Some misunderstandings are probably rather common. People may also lack knowledge about how to test for radon and whom to ask about testing and mitigation. They are especially uncertain about mitigation and its costs.

It is relatively easy to inform people about radon facts. However, there is little relation between knowledge and tendency to test and mitigate. This finding is in line with a generally noted lack of relationship between attitudes or beliefs and knowledge.

1.6. Mitigation of radon risk

There is a rather low correlation between scientifically estimated risk and mitigation, but a strong correlation between perceived risk and mitigation. This is an example of a quite general truth: people react to what they perceive reality to be rather than what it really is.

It is not yet clear how much mitigation one can expect in different circumstances. Some data (see Figure 2, page 50) certainly suggest that home-buyers are likely to be among the most responsive to the radon risk message. On the other hand, not all data on mitigation are as negative as the ones reported in the study of the Washington, D. C., television campaign. A follow-up of highly motivated New Jersey homeowners found a high rate of mitigation. Swedish data were in between the two American data sets. (Cultural comparisons are risky, however, since many crucial aspects, such as the economics of housing and mitigation, differ dramatically between Sweden and the USA).

1.7. Message format and contents

A few studies have investigated the format and contents of radon risk messages. A major study compared "command" and "cajole" styles of communication. That study also investigated and compared qualitative vs quantitative types of information. The results were somewhat complex and differences were not large but there was a tendency for a command style of communication to be most effective. That study also compared the use of a brief fact sheet as a replacement for more extensive brochures. It was found that those who had been given the fact sheet tended to be more concerned about their risk level than others. This was true in spite of the fact that the fact sheet was only given to those who had very low levels of radon in their homes.

The investigators concluded against the use of the fact sheet. That may be a reasonable conclusion for that particular group of homes and their owners. It may still be the case that a short fact sheet would be useful for people who have higher levels of radon measured in their homes. It has been found that people, if given the chance by rich information material, tend to construct defensive denial conceptions. In other words, more information makes it easier for them to come up with rationalizations for lack

of action. Of course, a short fact sheet need not be very similar to the one used in the NYSERDA study.

An experimental study of risk communication formats found that a brief statement about the action level was best for eliciting continued concern. On the other hand, full information about the risk, including numerical, comparison and graphical information, was best for creating a balanced view. A major difficulty was communicating absolute risk levels. A graphical display seemed sufficient to make people disregard a difference in absolute risk level in the range 1-25 (between radon and asbestos risks).

Another reason for favoring very brief messages is that people have difficulty in handling information and that they are not very motivated to obtain it. Studies of public service information in the form of printed brochures usually have shown that most people do not bother to read them and that those who do read them quickly forget most of their contents. Other investigators have studied the effects of level of risk communicated and found that a more threatening message tended to invite more risk denial. The conclusion is that the most effective message format and contents should be brief and not too threatening.

The conclusion should be regarded as preliminary. It is based on a rather complex set of findings from radon risk communication studies and from communications research in general, as well as basic principles of cognitive psychology.

1.8. Methodology

The empirical studies reviewed in the report vary considerably by methodology. Virtually all were quantitative and employed either mail or telephone survey methods but they differed in many other respects.

There is evidence that people are not very eager to participate in surveys of this kind. Response rates around 60 percent or lower are common in spite of several reminders. Some of the problems of low response rates have been attributed to data collection during holidays, but there is no evidence that these particular studies yielded especially low response rates. Indeed, the US public is saturated with opinion polls and survey investigations and it is becoming more and more difficult to recruit respondents for new waves of data collection.

Women seem to be more likely to accept invitations to participate in radon risk studies than men, and the result is that females are over-represented in some of the studies. Also, the samples tend to consist of highly educated and financially secure people, possibly because the studies have focused on home owners rather than renters.

Attitude change has been studied for decades. It is usually quite hard to change people's attitudes, especially to change them permanently and to affect behavior. Changes tend to be short lived. The empirical work on radon so far has not followed attitudes for a more than a few months, with the exception of the NYSERDA study. Longer follow-up times are called for in order to get a realistic idea about how persistent attitude changes are.

It would probably be fruitful to investigate in more detail how people reason with regard to radon and testing. One piece of information that is lacking in these studies is <u>why</u> people test (there is data on why people do not test). Testing can be motivated in many ways, for example health, economic factors or conformity to expectations by friends. The reasons people have for testing could stimulate the formation of hypotheses about effective methods of risk communication.

Qualitative information about the conceptions and misconceptions that people have about radon would also be of interest. Among other things, such conceptions could be of crucial importance for mitigation. Some people may believe that radon is most likely to be found in the attic rather than the basement of a house (since many gases are lighter than air). Ionizing radiation is also something that people know little about and have several misconceptions. A study of this type is under way at Carnegie-Mellon University.

There have been few attempts to analyze the contents of radon risk attitudes. So far, most data suggest that health concerns are most important. Many studies could have profited from a more extensive mapping of the components of risk attitudes, using one of the well known models of attitude measurement, such as that devised by Fishbein (Fishbein & Ajzen, 1975).

Another possibility involves switching to the common international measure Bq/m^3 rather than pCi/l. Since 1 pCi/l = 40 Bq/m^3 such a switch would involve larger numbers that could by itself have an effect (whether positive or not).

Many of the studies reviewed here used a risk concept that was not further explained to respondents, who were asked to judge such perceptions as size of radon risk. However, other research has shown that people interpret the word risk in various ways. There may be differences among genders and educational strata in whether respondents interpret risk as probability, as the size of the consequences or as a combination of these two concepts. Interpretations of results may be misleading if this factor is neglected.

Another interesting methodological aspect is the response scale. It is difficult to translate the judgment of seriousness of

a risk into subjective probability. On the other hand, it notoriously difficult to obtain valid judgments of small perceived risk. As an alternative, comparative risks often are used to assist people in judging small risks. The radon risk has been compared to the risks of smoking, for example. This approach is well worth trying but one should bear in mind that comparative risk judgments are more complex than absolute ones because they involve two risk levels rather than one. Risks are probably perceived in a context of several threatening events and conditions and the judgment of any given risk may well be affected by how certain other salient risks are perceived. For example, people with a very risky job may perceive their radon home risk as minor just because it is implicitly or explicitly compared to a job risk.

1.9. Social diffusion

In many circumstances people are most strongly affected by social diffusion of information and attitudes, i.e. what their friends, neighbors and locally prominent people tell them. For this process to spread quickly there must be many willing "informers". However, in the case of radon there are still very few people who have shown any active interest in the issue of home testing, and those who have informed their friends and neighbors have sometimes met with hostile reactions.

1.10. House values and house sales

There has been little work on property values and house sales as related to radon. A Swedish study recently found that radon did not seem to affect house prices. Informal information from realtors in the USA confirms this finding. However, a Colorado study showed that many people are quite concerned about getting a house tested for radon before they buy. Some 50 percent of the home-buyers participating in the study reported that they had done so. These people also tended to mitigate much more often than those who bought test kits and monitored their own homes. Indeed, the prevalence of testing at or above the action level of 4 pCi/l was 100-200 times as great for home-buyers as for homeowners. People whose employer was especially concerned about the radon risk and those who were in contact with a knowledgeable realtor or building contractor were especially prone to test and mitigate. These results were obtained in a state where radon risks have not been extensively discussed in the media (Colorado).

The fact that real estate prices are not affected by radon may be related to the prevalent information that a radon problem usually can be fixed quickly and fairly cheaply. There has been little awareness so far about how often continued monitoring for radon will be required and additional mitigation will have to

undertaken. When this issue is given wider publicity there could be an effect on real estate prices.

1.11. Missing information: groups not studied

Virtually all research so far has been conducted with homeowners so the social strata that have been represented have not been representative of the whole population. We do not know how people who rent their homes respond to radon risk, or how involved their landlords are in monitoring and mitigating such houses. There is also very little work reported about attitudes to radon in schools, public buildings and workplaces.

1.12. Conclusions

Research on radon risk perception and risk mitigation has not proceeded very far, simply because the problem is so recent. However, it is possible to draw some conclusions on the basis of existing research results.

(1). The major problem is indifference to high-level risk, especially among people who already live in a home that may have an elevated radon level.

(2). Home buyers are probably much easier to alert to the issue, with ensuing radon testing and mitigation if called for.

(3). Studies of variations in risk communication material suggest that brief, to-the-point recommendations about what to do are better than longer messages that allow the reader to form his personal opinion. It is just too likely that these personal opinions will be defensive risk denials.

(4). Even the most effective mass media campaigns and outreach community programs investigated so far have succeeded in stimulating only a small fraction of the population of homeowners to monitor and mitigate. Whether these campaigns have still justified their costs has not been determined. A community outreach program appeared to be more promising than a major television campaign, although they probably reinforced one another.

(5). Further research should be conducted on the components of radon risk attitudes and conceptions, in particular why some people test and mitigate. Interpretation of findings would probably be helped by more information on how people interpret such key terms as "risk".

(6). There are important ethical aspects of radon risk that have been neglected in research. Some people see nobody as responsible

for a radon problem, others may blame themselves, contractors o[redacted] the government. The owner of a house may or may not fe[redacted] responsible for the health of others who live in it. At the tim[redacted] of a house sale there is a special ethical problem if the seller knows there is a radon problem. These are important matters for further research.

(7). There is a total lack of data on how renters, as opposed to homeowners, perceive risk and how their landlords view the radon issue. There is very little data on the perception of radon risk in public buildings and workplaces. Perhaps some homeowners can be alerted about their home risks if they get involved in school building risks.

(8). Although the sparse data that exist on the issue suggest that radon risk does not reduce property values, the issue certainly needs much more investigation. Will the lack of effect persist when more experience with mitigation and its costs and effects accumulate? People may at this time be overly optimistic about how easy it is to "fix" a radon problem permanently. Do people see monitoring as a potential economic threat? Or will <u>lack</u> of monitoring and disclosure of results at the time of a house sale be the real economic threat in the sense that homes that have not been tested will sell for a lower price?

"Don't expect too much. People can understand risk tradeoffs, risk comparisons, and risk probabilities when they are carefully explained. But usually people don't really want to understand....Over the long haul, risk communication has more to do with fear, anger, powerlessness, optimism and overconfidence than with finding ways to simplify complex information." (Sandman, 1986, p. 23).

2. Introduction

Radon is a colorless and odorless gas that is emitted from uranium in rock and soil. It can enter houses through cracks and openings in foundation walls and floors, drains or ventilation systems, or by being released from water[1] from underground sources. It is radioactive[2]. In addition to naturally occurring radon, there is some radon emitted from building materials. About 10 percent of the indoor radon in the USA is estimated to emanate from building materials (Krimsky & Plough, 1988).

There is consensus among experts that prolonged exposure to high levels of radon can cause lung cancer. This consensus is based on data on the prevalence of lung cancer among uranium miners (National Research Council, 1988) and general knowledge about the health effects of ionizing radiation.

Radon has been named as the most serious environmental health hazard threatening the American people (Lafore, 1987; US Environmental Protection Agency, 1987 b; Kerr, 1988), and most experts agree that radon is the most serious indoor pollutant. The average indoor radon level in the USA is estimated to be 1.5 picocuries per liter of air[3] (pCi/l), the outdoor level to be 0.2 pCi/l.

Data on indoor radon levels are available also from other countries in North America and Europe. The following data (see

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[1]. See the special issue of American Water Works Association Journal, 1987, 80, No. 7.

[2] When radon releases its ionizing radiation it is transformed to so-called radon daughters, the radioactive isotopes P_o218 and P_o214 which constitute a more dangerous threat than radon itself. When they are inhaled and deposited on the bronchial tree they can be carcinogenic.

[3]. 1 pCi/l means that about two radon atoms per liter of air decay per minute.

Table I) were compiled by Åkesson, Bergman and Johnson (undated) based on data from the Swedish National Institute for Radiation Protection (1987) and Nero (1989).

Table I. Distribution of radon exposure in various countries.

		Percent of homes that exceed		
Country	Mean pCi/l	2.5 pCi/l	5 pCi/l	10 pCi/l
Sweden Norway Finland	1.3	10	3	1
USA	1.5	12	4	1
Canada	0.7	3	1	0.2
West Germany	0.7	0.7	<0.1	-
Great Britain	0.3	na	0.2	<0.1

It is worth noting that, according to these figures, the radon problem seems to be somewhat worse in the USA than in other countries where measurements are available.

EPA has estimated that 12 percent of the homes in the USA may have radon levels exceeding 4 pCi/l, which is the lowest level for EPA's official action guidelines[1]. Later estimates of 20 percent have been mentioned (Krimsky & Plough, 1988).

Cohen & Gromicko (no date) compiled a large number of radon measurements (about 35 000 homes) and presented results which probably give a good picture of the situation in the USA as a whole. They found that the distribution of radon concentration was skew[2], with an excess of houses with very high levels. One house in

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[1]. EPA's action guidelines are not health-based standards. They are recommendations based both on health considerations and what was judged to be achievable in terms of reducing indoor radon levels at reasonable cost.

[2]. Averages were typically twice the median and only 24% of the houses were above average.

1000 was estimated to have a radon level 100 times or more above the mean. They also found that there was a seasonal variation (about 60% higher values in the winter), and a low correlation with the age of the house. Basements had 2-3 times higher concentration than livingrooms. Weatherization activities since 1974 were estimated to have increased radon levels by about 15%.

Lifetime exposure to EPA's action level of 4 pCi/l has been estimated to carry a 1-5 percent increased risk of lung cancer. It is estimated that the lung cancer risk of 20 pCi/l corresponds to smoking more than a pack of cigarettes per day. Of all lung cancers not related to smoking, 10-50 percent are due to radon exposure. Smokers are more seriously affected by radon than nonsmokers (National Research Council, 1988).

Risk estimates are seldom final, of course. Estimates of the risks of low-dose ionizing radiation are based on data from survivors of the Hiroshima and Nagasaki bombs and there is considerable controversy about those data. Recent revisions of interpretations of Hiroshima and Nagasaki data imply that the risks are probably between 5 and 15 times as large as previously believed (Rotblat, 1988). The extrapolation of radon risks from data on uranium miners is uncertain because home radiation generally is much lower and because working in a mine is a very different activity from being at rest at home. However, it should be noted that some homes do have levels as high as those observed in the epidemiological studies of miners. Also, not all the time spent at home is spent resting. Some of it can involve physical exertion similar to that in mines. It has also been pointed out that there is no sizable positive correlation between the prevalence of lung cancer and radon statistics across regions.

Since controlled experiments on humans are ethically and legally unacceptable there is bound to be continued controversy. This can be compared with the risks of fluoride in drinking water, for which there is still considerable uncertainty about the issues despite 40 years of investigation (Hileman, 1988).

Until 1985[1], there was little attention in the United States to high radon levels in residential buildings, resulting from geological radon. The problem had been discussed earlier in other countries (Sweden and Canada), and it had been mentioned in a UN

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[1]. In December of 1984, Stanley Watras, a resident of Boyertown, Pennsylvania, set off radiation detectors as he entered his place of work, Philadelphia Electric Company's Limerick generating station, a nuclear power plant. A subsequent test of his home showed that it measured 2700 pCi/l. The lung cancer risk of this level of radon exposure has been estimated to be equal to that of smoking 280 packs of cigarettes per day.

report in 1977 (United Nations Scientific Committee on Effects of Atomic Radiation, 1977). This is in spite of the fact that there was considerable concern in the 1970's about radon emanating from man-made sources, such as uranium mill tailings and phosphate slag in building materials. The EPA was criticized in the early 1980's for its concern over radon risks from mill tailing piles, which were seen by some as minor in relation to the risks from geological radon.

EPA had published a risk estimate (5000 - 20 000 lung cancer deaths per year in the USA due to indoor radon) in 1979 (Guimond et al., 1979). The current official estimate is about the same.

Since December of 1984, the problem has been intensely analyzed and it is now known that many homes in the USA are likely to have radon problems, perhaps as many as 8 million of the nation's 70 million homes. It is the federal policy that every home in the USA should be tested for radon. There is, however, no legislation that forces any private citizen or any government agency to do so. It is up to the individual to monitor his or her own risk level, and to take appropriate action.

It is relatively easy and inexpensive to test for radon. It is also usually rather straightforward to mitigate against any radon problems that might be discovered in testing, by means of improved ventilation, sealing of holes and cracks, etc[1]. Still very few people have tested their home for radon (less than 5 percent of the US homes as of November, 1988).

The population's indifference to home radon risks starkly contrasts with the strong reactions observed in the New Jersey community of Vernon to the proposed deposit of soil somewhat contaminated by industrial radioactive wastes (Chess & Hance, 1988). The enraged people of Vernon who threatened civil disobedience (and were successful in avoiding having the contaminated soil deposited in their community) were some of the same people who did not bother to test for radon risks in their homes - risks that were, according to experts, much larger. Outrage over risks from toxic waste has, of course, been noted many times, e.g., in the case of Love Canal (Mazur, 1984).

Because the radon problem was discovered only recently it is only natural that rather little research has been carried out on the perception of and attitudes toward radon risks. Still, the acute nature of the problem has motivated some rather extensive attempts at mapping people's reactions to radon risks and to

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[1]. The question of how often such repairs need to checked and improved in the future has been rather little discussed. A radon problem is, of course, seldom solved for as long a time as the lifetime of the house.

investigate the effectiveness of risk communication methods in this area. This report reviews these studies, draws conclusions from them, and suggests topics for further research. The reader is also referred to Fisher and Sjöberg (in press).

I will concentrate on the reactions of homeowners to radon in their own homes. A few researchers have collected additional information about people's reactions to radon risks in public buildings and to taxation aspects. While these problems certainly are important, I feel that there is as yet too little information to warrant detailed coverage. The importance of radon risks for property values is another aspect that so far has not been treated thoroughly in empirical research.

Before discussing current research I will sketch the development of public radon awareness and attitudes in the USA.

3. Information, the media and radon

Mazur (1987) has described in some detail how radon came to be an issue on the public's risk agenda. Radon risks did not receive national attention in the USA until 1985. Risk estimates had been published in professional journals and by the EPA several years earlier but with little impact.

There was (and perhaps still is) a wide spread belief in the positive effects of radon. On November 25, 1984, just before the Watras incidents, the New York Times had the following to report:

> "People suffering from arthritis, headaches and other ailments come from all over the world to seek cure in former gold, silver and uranium mines in southwestern Montana, whose rock-walled tunnels emit radon, a radioactive element produced by natural decay of uranium; among physicians reactions range from charges of quackery to tacit blessings for patients who have no other relief". (New York Times, November 25, 1984).

The New York Times Index offers some further information on the issue. There was a rather alarmist article published already in 1980, citing among other things some Canadian data, but it seems not to have had much impact on the public. Then, the newspaper was almost silent on radon issues until 1984. The New England Journal of Medicine published an editorial in the spring of 1984, mentioned by the New York Times on June 7, 1984. The editorial stated that there may be up to 100 000 cancer deaths among non-smokers every year in the USA. The statements made by physicians can be assumed to be of special importance for public opinion.

The Watras incident (see page 13, note 1) was of critical importance for alerting the public to radon risk. In addition, a few weeks before the Watras incident (in December, 1984) the home

of Joel Nobel, which measured 55 pCi/l, had received so publicity, even on national television.

The Watras family evacuated their house, "in some panic" (Mazur, 1987, p. 89). The Pennsylvania DER then conducted a survey of some neighboring houses, found some elevated radon levels, although nothing close to the level in the Watras house, and informed a township commissioners' meeting on January 7, 1985. After that, local news media were quick to report the Watras event and it was given wide spread local attention. However, according to Mazur it was ignored by national media until May, 1985, when a first page article appeared in the New York Times[1]. Other national media then picked up the story and concern about radon rose significantly, leading to renewed activities by the EPA.

Mazur points out that the current risk estimates agree well with those published in the 1970's. Strictly speaking, radon is not a "new" risk, and the fact that it was ignored for almost a decade needs an explanation. The risk itself is larger than many of the other risks that people have cared about and that EPA has regulated, so its size cannot explain the lack of concern. According to Mazur, the limited publicity that had occurred in the Nobel case, just before the Watras incident, was an important factor in sensitizing the public (and decision makers). The vigilant response by the Pennsylvania DER did much to add moment to the issue. It can be added that the sheer magnitude of radiatio measured in the Watras house was quite surprising. It established a possibility of disastrous radiation in a home, which had not been expected before. Finally, perhaps the connection to nuclear power (Watras worked in a nuclear power plant) may have added some attention value.

Following the Watras incident there was considerable mass media attention to radon in the USA, especially in the East. The fact that the Watras family had evacuated their home made a strong impression. It has been suggested that apathy might be lessened if it were made known that a nearby family had evacuated their home (Chess & Hance, 1988). The contents of local Pennsylvania newspapers during the first nine months of 1985 were compared to national media by Friedman et al. (cited by Lehrer, 1988). They found that local newspapers gave much more attention to the radon issue than national media but that headlines tended not to be alarmist, avoiding such words as cancer and threat. Local editors said they wanted to avoid panic and adverse effects on the housing market.

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[1]. However, the New York Times had carried an article abou elevated radon levels in New Jersey homes already on February 17, 1985.

According to Sandman (1986), the strong initial response in Pennsylvania and New Jersey soon tapered off. In the New York Times there was a tremendous increase in the number of radon related articles in 1985-86, but in 1987 the number dropped, see Figure 1. Sales of test kits went down in the winter of 1987 compared to one year earlier (Sandman, Weinstein & Klotz, 1987). Sandman explained this by the facts that radon risks are chronic, not acute, events, and that there is no obvious "villain" or social and political conflict involved.

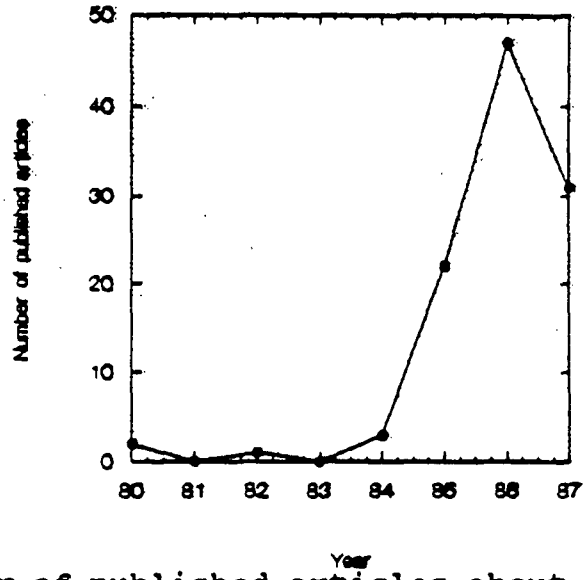

Figure 1. Number of published articles about radon in the New York Times, 1980-87.

It is clear that few people actively seek information about radon. When it comes to media and other sources of information they tend to trust local scientists, the EPA, and possibly newspapers. The attitude toward local government agencies varies.

4. Characteristics of radon risks

It is difficult to predict how people will respond to new hazards. When indoor radon in homes was first widely discussed in the USA there were some expectations among administrators that people might panic (Sandman, Weinstein & Klotz, 1987). The opposite occurred. The reasons for this indifference constitute a crucial problem in communicating about radon risks.

A number of factors that have been mentioned as explanations for the lack of urgent responses to radon risks.

A.There is no "bad guy" responsible for the risks from geological radon. The existence of a villain to blame for a risk has been singled out as an important factor in accounting for public outrage (Baum, Fleming & Davidson, 1983). An often quoted comment by a

participant in a focus group is "What are we going to do, sue God?" (Desvousges & Kollander, 1986). This factor may be related to the lack of a discrete source - be it an object or a person - responsible for the risk[1].

B. The hazard is a natural one, not man-made. People tend to underestimate the risk of natural hazards (e.g. Kunreuther et al., 1978; Lehman & Taylor, 1987). The reason for this underestimation may be that nature is seen as benevolent, or it is believed that we are biologically adapted to it. In Sweden, the initial strong reaction against radon was probably due to the belief that it was caused solely by building materials. When it was later found that most of the problem was caused by naturally emitted soil gas, protests dwindled.

C. The hazard cannot be sensed, so it tends to be underestimated. It has been suggested that if radon was not odorless there would not be a radon problem.

D. The illness, lung cancer, does not give early warning signals and takes a very long time to develop.

E. It is not possible to identify, in concrete cases, that radon has caused a person's lung cancer. Lung cancer deaths are undramatic and occur singly.

F. Persons typically have a long history of benign experience with their homes.

G. The choice of a home is under one's own control, so the risk may appear to be "voluntary". This point can be disputed. Lehrer (1988) compared it to such life style risks as smoking which also calls for protective action by the individuals exposed to the risk. He judged radon risk to be clearly involuntary.

H. The risk is highly variable from house to house and depends on a number of factors that are hard to understand completely.

I. Testing and mitigation are complex and new activities that people know little about.

Against these factors that are believed to reduce risk perceptions there are a few that might work in the opposite direction:

J. The risk is relatively unfamiliar and new.

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[1]. This idea was suggested by Amos Tversky.

K. Testing is simple and cheap, and mitigation relatively so, in most cases. These facts are likely to moderate the tendency for risk denial.

L. The risk is, after all, a cancer risk and cancer is a much feared illness.

And, finally, some factors are ambiguous:

M. Extensive mass media attention, such as that recently given to radon, should increase risk awareness and increase the perceived level of risk. On the other hand, mass media attention is never constant. In the case of radon it is probably tapering off from an early peak in 1985-86.

N. Radon threatens people in a very personal and serious manner. This makes it subject to the phenomenon of risk denial, which is very common when it comes to health risks.

O. There are no benefits from radon exposure. This factor distinguishes it clearly from life style risks, where there is usually a temptation due to the pleasure that follows upon consumption.

Some comments are in order. It is illustrative to compare radon with a well known highly threatening risk, such as the risk of nuclear power (cf. Sjöberg & Drottz, 1987).

The lack of a "bad guy" is a factor that may be more true of radon than of nuclear power. It has some anecdotal support as reducing perceived risk, but no theoretical underpinnings.

Many risks that people fear strongly cannot be sensed. Both radon and nuclear power cannot be sensed but there is widespread fear of nuclear power. Thus this factor can hardly explain indifference to radon risks.

Cancer with a long latency between exposure and illness is a characteristic of both radon and nuclear power risks. The long latency factor cannot explain why people ignore radon risks.

The more unique factors in the case of radon appear to be mainly that is a natural hazard and that it is related to one's home and under one's personal responsibility and control, as compared to nuclear power risks or smoking. Furthermore, it is easy to delay action about radon, because there are no obvious adverse consequences from postponing testing (or mitigation) for some time.

Radon risk communication also needs to be viewed in the perspective of risk communication and health promotion in general. It has been found repeatedly that it is very hard to induce health

promoting behavior (Adler & Pittle, 1984). Some more optimist[redacted] results were reported by Viscusi, Magat and Huber (1986) and Puska et al. (1979). The former was concerned with a laboratory simulation, however, and the latter with a very extensive mass media campaign, much more extensive than would be realistic to consider in the USA.

Thus, risk communication is difficult and rather little is known about how it should be carried out most efficiently in any given field. In addition, risk advisory programs at EPA have seldom been evaluated (U.S. Environmental Protection Agency, 1987).

Current EPA sponsored activities constitute a response to this need for research. Several attempts (by EPA and others) have been made, and others are underway, to study empirically the properties of radon risk perceptions and attitudes and how risk communication can be improved. This work is reviewed in next section.

5. Empirical studies of radon risk perception and attitudes

5.1. Introduction

In this section, brief descriptions will be given of each of the studies carried out so far. The general strategy in reporting the studies has been to begin with a seminal investigation of somewhat limited scope, to continue with preparatory work for more extensive studies, then to deal with the three major studies of risk perception and radon monitoring that have been carried out, and finally to treat a number of smaller and more specialized investigations. A special section, see page 41, is devoted to work on mitigation, which is more recent and not yet as fully developed.

5.2. Maine study

5.2.1. Design and selected results

Johnson and Luken (1987) analyzed data from 230 Maine households, who were interviewed in the fall of 1985. The respondents had participated in a lung cancer epidemiology study. They had received radon measurements of their homes and a University of Maine radon information pamphlet.

Data were collected on risk perceptions, mitigating activities and socioeconomic characteristics. The risk judgments were both of current risk perception and what the respondents remembered that their risk perception had been before they obtained the radon readings.

Johnson and Luken found that information about radon chang[redacted] risk perceptions, and that mitigation activities tended to lower their personal risk estimates. However, they also found that

mitigation was equally likely for those who had obtained low radon readings as for those who had obtained high readings. The respondents greatly understated their radon risks, with few exceptions. In spite of this, about half of them reported some kind of mitigation.

A subset of these data were also analyzed by Smith and Johnson (1988). They could use data from only 117 of the 230 respondents, due to missing data. It was found that people adjusted their risk estimates according to the information they obtained, in line with a simple Bayesian model. They also confirmed the Johnson & Luken finding that individuals who took some mitigating actions reported lower risk perceptions after that action.

Smith and Johnson stated that these results suggest that people may be more rational than previously believed and that they may be open to new information about risks and adjust their risk estimates accordingly.

5.2.2. Evaluation

This study is obviously of limited scope. The sample was small and consisted of a very special group of patients and the data collected were not very extensive. The study was important mainly because it initiated an interest at EPA in conducting further work on radon risk communication.

The claim to rationality in people's risk perception made by Smith and Johnson is similar to a claim made in the NYSERDA[1] study, next section, and it will be discussed more extensively in that context. However, it must be noted here that the use of retrospective risk estimates is not very satisfactory. Clearly, there is no support for the implicit assumption that people can remember and correctly report what risk perception they used to have. On the contrary, Fischhoff's well known studies of hindsight bias (Fischhoff & Beyth, 1975) have demonstrated that people consistently distort their memories of earlier judgments, to be more in line with information current at the time of judgment. Smith and Johnson were well aware of these limitations, of course.

5.3. Focus groups

5.3.1. Design and selected results

EPA sponsored several focus groups on radon. Desvousges and Kollander (1986) reported initial trials with 6 focus groups. They were conducted with homeowners having different degrees of awareness of the radon problem. The purpose was to evaluate

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[1]. New York State Energy Research and Development Authority.

information materials to be used in the NYSERDA study and to g[redacted] some preliminary insights into radon attitudes. In the second focus group study (Desvousges and Cox, 1986) two groups of homeowners who had tested their homes for radon participated. Preliminary versions of two of the NYSERDA booklets were evaluated. A further activity, preliminary testing of materials to be used in the Maryland study, involved four groups - two in Pennsylvania and two in Maryland (U.S. Environmental Protection Agency, 1987 a). Both testers and non-testers of different educational backgrounds participated. The purpose of these four groups was to probe why some people had tested for radon while others had not. Results from all of the focus groups were used to plan further, more precise and extensive work.

Focus groups are useful for getting qualitative information about the important factors in any attitude study. They cannot give information about how common the opinions are, or about strength of relationships, in a population (Desvouges & Smith, 1988).

Some of the findings were:

- Quantitative information was often called for, as well as risk comparisons.

- Nonsmokers were more satisfied with comparisons to smoking ris[redacted] than smokers who found such comparisons "confusing".

- Color coding of risk charts was rated favorably.

- People were unhappy and confused when informed about uncertainty in risk estimates.

- Some people preferred numerical risk estimates, others verbal labels and still others graphical information.

- People wanted answers to concrete questions such as "What is my risk" and "Where can I get information about mitigation".

- Some found the risks charts too scary, others liked them to be scary.

- Testers had (with one exception) spoken to friends or family members before deciding to test.

- Non-testers showed the familiar denial dynamics, i.e. they did not believe that they themselves were at risk, and they found special reasons for "proving" that view. (Radon risk is not well understood by experts, the risk is only one among many, "everything gives you cancer", "Three Mile Island is much more of a dang[redacted] to me").

- Concern about property values could both motivate testing and cause people to abstain from testing.

- Many non-testers believed that mitigation would be difficult, expensive and risky.

- Information about radon was mainly obtained from newspapers and television. EPA and state environmental agencies were rated highest in credibility.

5.3.2. Evaluation

These were relatively minor studies performed as part of designing the NYSERDA and Maryland studies to be described in following sections. Work of this kind cannot provide quantitative estimates of the frequency of various opinions or the importance of factors determining attitudes and behavior but it can give a rough idea about what factors are important.

Some interesting information from these groups has not been tested in subsequent research. For example, there may be individual styles of information processing since some people prefer verbal information, others graphical. Perhaps information could be tailored to fit these styles. Another idea is the use of appropriate comparative risk. There was some indication that smokers did not like smoking as a comparative risk. Perhaps smokers tend to deny risks of smoking and therefore are confused when smoking risks are brought in as a reference norm. At any rate, if comparative risks are used it seems important to get independent measures of how the reference risks are evaluated.

5.4. NYSERDA study

5.4.1. Design and selected results

This study (Smith, Desvousges, Fisher & Johnson, 1987, 1988), was an attempt to test different approaches to risk communication. The participants in the study were homeowners in the State of New York who had agreed to participate in a state-wide sample organized by New York State's Energy and Research Development Authority (NYSERDA). NYSERDA's objective was to test a sample of homes in the state for radon in order to map the prevalence of radon problems in the state.

Baseline data concerning risk perception and knowledge about radon were collected while the radon monitors were in place. The same data were collected for a comparable non-testing control

group[1]. Brochures were then sent to the homeowners in the monitoring group together with information about their radon levels[2].

The NYSERDA sample was divided into several groups, with each group receiving a different information treatment. Four brochures contained information about risk levels and mitigation. They differed with respect to two dimensions: (a) Whether information about the risk level was given in quantitative or qualitative format and (b) the tone of the text which was either directive ("command") or evaluative ("cajole").

The command tone emphasized what an expert (in this case the EPA) recommended as the appropriate response to the risk level while the cajole tone encouraged the recipient to form his or her own opinion on the basis of the information presented.

The four brochures contained the same information except that only the cajole brochures contained information about how to adjust the test result to reflect different lengths of exposure. Households with a radon level of at least 1 pCi/l also received EPA's mitigation brochure[3], but mitigation was discouraged on the basis of a 2-3 month reading alone.

Other groups received EPA's Citizen's Guide or a radon fact sheet developed by the State of New York (and similar to fact sheets used in other states). All treatments involved giving the homeowners the same information except that the fact sheet had less information. It was, however, sent only to a subset of those who had test results of less than 1 pCi/l.

Baseline data were obtained in the summer of 1986 and the first follow-up interviews were carried out six months later (telephone interviews). A second set of follow-up data was obtained in the period September, 1987, to January, 1988 (mail questionnaires), after the annual radon readings had been sent to the homeowners.

2300 homeowners participated in the NYSERDA study, and there were 252 nontesting homeowners in the comparison group. The response rates for those participating in the NYSERDA study were high: 97 percent in the baseline interview, 91 percent in the first

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[1] There is some doubt about the status of this control group. It should perhaps more appropriately be called a comparison group. It was selected later than other groups, it had a low response rate and there may have a been a self-selection bias in the monitoring study. The comparison group was selected using the same protocol as the original monitoring sample, though.

[2] Two sets of measurements had been carried out: a short-term measure (2-3 months) and two annual measures (12 months).

[3] Radon Reduction Methods: A homeowner's guide.

follow-up and 74 percent in the second follow-up. 50 percent of those approached for the comparison group agreed to participate.

Three major questions were analyzed:

(1) Which information treatment led to the most learning?

(2) Which was best in helping people form realistic perceptions of their radon risk?

(3) Which was most effective in making them feel that they had enough information to make a decision about whether to take action?

Knowledge about radon increased in all treatment groups, but the increase was smaller for those who only received the fact sheet. There was also an increase in the comparison group's knowledge. The respondents turned out to be fairly knowledgeable when it came to radon measurement, less so with regard to risks and mitigation. The four brochures seemed to work about equally well in this respect, with a possible advantage for the cajole qualitative brochure, which facilitated learning about radon more than other brochures. The quantitative brochures were best for communicating risk levels. A higher radon reading also seemed to go together with a higher level of knowledge. Older people (over 40) knew less. Education was a positive predictor, and so was early awareness of radon (measured at the time of the baseline measurement).

Why did the particular NYSERDA brief fact sheet work so poorly? The major reason is probably the very special circumstances of testing it. It was used with people who had very low radon levels in their homes. Hence, the normative response was to decrease concern about the risk. The fact sheet probably did poorly because of this peculiar circumstance. People who have not yet tested or who have tested and obtained a high radon reading should be encouraged to test or to mitigate, and such groups were not given the brief fact sheet in the study.

Personal radon risks were perceived as lower than general population risks of radon. Personal ratings were also more influenced by information, and far fewer people answered "Don't know" to the personal risk question in the first follow-up compared with the baseline. Memory of readings of lifetime risks from risk charts was better for homeowners who had received the experimental brochures than for those who had received the EPA Citizen's Guide. Those who had obtained higher readings were more likely to remember incorrectly.

It was found that people updated their risk estimate somewhat in accordance with the radon reading that they had received. Young and well-educated people were most likely to do so. The updating

results were different for the first and second follow-ups however.

For the first follow-up, the radon readings (living area) were generally low (average = 1.39 pCi/l, range = 0-39.8 pCi/l). The average risk perceptions dropped by some 20 percent (Johnson & Fisher, 1989). Johnson and Fisher suggested that there still may be an overall tendency to overstate the posterior risk, i.e. to adjust the risk ratings too little downward[1].

This finding is important, and goes against the general finding in other studies that there is only a weak relationship between perceived radon risk and actual risk. However, this is the only study as far as I know that has investigated changes in radon risk ratings before and after a reading of the actual radon level has been obtained.

The NYSERDA brochures led to a lower rating of radon risk than the factsheet, especially the quantitative versions. Those who received the factsheet tended to remain concerned (in spite of the low readings, always <1 pCi/l), and were interested in paying for more information and guidance. The estimated willingness to pay was the second highest for this group, and 80 percent (the highest figure of all groups) said they wanted more radon risk information. Smith et al. (1988) concluded that giving very little information about a risk may increase worries about it rather than the other way round[2]. Those who made more effective use of the brochures were less likely to demand more information, as were, in particular, older respondents.

For the second follow-up, the radon readings were somewhat higher than for the first follow-up. The average living area measure was comparable, but the basement reading was twice as high (average = 3.37 pCi/l, range = 0-114.9 pCi/l). The result was that respondents adjusted their risk estimates upwards, especially if they had received the command/qualitative NYSERDA brochure. This brochure encourages thinking about the radon risk as related to a

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[1] This may be an example of the often observed tendency of intuitive judgments to be too conservative as compared to the normative Bayesian model.

[2] However, the contents of the information may be just as important. The fact sheet contained some basic information about radon and its measurement, and about EPA's recommended action levels. The fact sheet did not specifically state that a level below 1 pCi/l is nothing to worry about. It did state that the two-month reading "should not be directly compared" to the EPA guidelines, because it was not an annual concentration and because it was for a specific location only, not for a whole house.

threshold (of 4 pCi/l). Those obtaining basement values exceeding the threshold consequently had a rather strong increase in perceived risk[1].

The conclusion of this report is that the cajole/qualitative brochure was best at stimulating learning about radon while the two quantitative brochures did best at providing a more realistic risk estimate. All booklets did about equally well in reducing the demand for more risk information.

The findings indicate that none of the four employed variations is best in all respects but the over-all performance seems to be best for a command/quantitative approach, which combines clear directions for action with precise information. The NY fact sheet is judged to be too brief and also misleading, since those homeowners who had less than 1 pCi/l still were worried if they had received the fact sheet.

The latter conclusion may have other implications. If people on the whole underestimate radon risk it may be that the fact sheet format is useful in promoting a more vigilant attitude.

5.4.2. Evaluation

At the time of writing, this project is not yet finished. Only preliminary mitigation data have been collected but they are not yet analyzed. The full set of mitigation data were collected early in the spring of 1989, but no analysis is available at the time of writing this report (August, 1989).

The study is, however, one of the most important and ambitious attempts at studying radon risk communication. The design was very carefully planned, response rates were excellent and the data analysis is quite exhaustive.

Some limitations should be noted. There are no data on testing decisions because NYSERDA had already contacted homeowners and gotten them to agree to participate. It is not known how representative these homeowenrs were or how many were approached and declined to participate. Furthermore, there is some information suggesting the NYSERDA sample homeowners were not representative when it comes to radon awareness.

The choice of the two independent variables (cajole/command and qualitative/quantitative) for designing the four brochures seems a bit arbitrary, and the report does not explain in full how

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[1] It would be interesting to analyze the data separately for those who received readings crossing the threshold, or to investigate any lack of linearity in the relationship between perceived risk and basement radon reading.

the group of experts reasoned when they recommended the particular variables. The researchers state that these factors we considered to be the most interesting ones because the experts thought they might make a big difference and because they tended to disagree about how the factors might differ in their effects.

There is, of course, a vast number of possible variations on risk information messages and the empirical research is, so far, not very extensive. Maybe it would have been better to start by performing rather extensive pilot work to be able to zero in on the most efficient designs for risk communication. As it now stands, the study gives merely a single piece of information about a few selected designs, which, as it happened, did not differ much.

The study also takes an unusual approach in expressing concern that some people may exaggerate radon risk, rather than neglect it, which is by far the most important problem in the area. The brief fact sheet could well have been distributed also to people with high radon levels. It would have been interesting to see if it works well in those cases. The present data, obtained only from homeowners with very low radon levels, suggest that the fact sheet or something similar may defend its place as an efficient means of risk communication when people tend to neglect a risk.

The finding that people tend to revise their risk estimat in the right direction is not inconsistent with a lack correlation between technical and subjective risk levels, often noted by psychologists. The reason why there is no positive correlation between technical and subjective risk may simply be that people quite rarely receive explicit risk estimates. In this situation, their risk perception is prey to all sorts of subjective bias factors and personal tendencies.

5.5. New Jersey study

5.5.1. Design and selected results

This is one of the earliest and most ambitious studies of the public's response to the radon threat (Weinstein, Sandman & Klotz, 1987). The authors investigated two samples:

1. Random sample: Owners of single-family homes in New Jersey in the Reading Prong area or near it. Data were collected in April of 1986. People who said they never heard of radon were excluded. 61.7 percent of eligible households participated. They tended to have higher education and higher income than the overall population of this region. Mean age was 47.4 years.

2. Confirmatory sample: All households who had contacted Ne Jersey's Department of Environmental Protection after havi

obtained a reading of at least 4 pCi/l through June, 1986. The net completion rate for this sample was 43.3 percent. Data were obtained in May-July, 1986. This sample had very high levels of education and income, and more males than in the random sample.

The respondents had high trust in authorities. Many basic facts about radon were well known, a bit less when it came to health-related effects. The subjects underestimated the seriousness of radon health threats. It was apparently much easier to find reasons to expect that one's own home had less radon than the average (247 reasons given) than why it could have more radon than the average (45 reasons given). The subjects of the random sample did not seek information actively.

Emotional reactions were discussed as related to decisions to test for radon, unrealistic optimism, explicit emotional reactions, community interactions and views on blame and responsibility.

Few respondents had monitored, and there were signs of apathy rather than panic. There was clear evidence of unrealistic optimism when it came to personal radon risks. Direct ratings of emotional responses indicated moderate to high concern and moderate worry, but levels in other aversive emotions (anger, fear, etc) were low. The confirmatory sample did not show any different emotional reactions than the random sample, in spite of having found elevated radon levels in their homes. Those who had monitored felt high in concern and low in helplessness, while those who had not even thought about monitoring felt low in concern and high in helplessness.

Blaming nobody for the radon risk correlated with monitoring, as did willingness to pay for remediation.

Weinstein et al. asked about reasons for not testing, and obtained the following results (see Table II).

The data suggest that people have not tested because they have too little information or that they have given a test low priority. This is a "rationalistic" picture of their (lack of) action. It is to be expected that people wish to describe themselves as rational. For that reason, it may be that the reasons given in the table to a large extent are due to a strategy to exhibit a rational way of behaving.

Klotz, Weinstein and Sandman (undated) found that the actual radon level had little to do with emotional distress. It correlated only weakly with perceived risk and perceived difficulty of remediation. Respondents were also concerned about potential economical losses.

Intention to remediate was not correlated with income and education, nor with the cost, feasibility and efficacy of radon

Table II. Reasons for not testing for radon (from Weinstein et al).

Reason for not testing	Percentage
Don't know what method is best	45.8
Don't think I have a problem in my home	42.4
Just haven't gotten around to it	35.9
Don't know how to get the test carried out	32.2
Will wait to see what others in community find	26.8
Wouldn't know what level is safe anyway	14.9
Costs too much	8.5
Don't think tests are reliable	7.1
Think results wouldn't be kept confidential	6.4
Reducing radon levels is too expensive	5.8
Didn't know it was possible	5.4
Neighbor's readings were low	3.4
Not interested	2.4
I'd rather not know if there is a problem	2.4
Too much trouble	1.4
Nothing can be done about radon anyway	1.4

Note. People were asked this question if they planned to test, were undecided, or thought a test was not needed.

reduction. Radon levels correlated weakly with intentions mitigate.

5.5.2. Evaluation

This study is especially interesting because of its attempt to map psychological factors of importance for understanding how people react to radon risks.

The traditional psychometric approach employed here differs somewhat from the more econometric approach taken in the NYSERDA study. However, the methods of the NYSERDA investigators are based on multivariate linear models, just as the ones used by Weinstein and collaborators. There is no reason to believe that the choice of statistical method is very important for the conclusions drawn here, and, in particular, that it can explain the somewhat different pictures of risk perception that have emerged.

It is interesting to compare the NYSERDA and New Jersey studies with reference to their general orientations to rationality. The NYSERDA investigators looked for rationality and found it in risk revisions, while the New Jersey investigators looked for lack of rationality, and found it in risk denial and lack of relationship between subjective and technical risk.

Reasons for neglecting to act given by the respondents in the New Jersey study may not have been the real ones. People tend to rationalize and to hide reasons which they believe are socially unacceptable. This suspicion is supported by a general lack of rationality in other aspects of the behavior observed here. There was little correlation between technical and subjective risk levels, and between mitigation and intentions to mitigate and technical risk. Also, there was clear evidence of risk denial in these data.

5.6. New Jersey experiment on radon information

5.6.1. Design and selected results

Weinstein, Sandman and Roberts (undated) mailed radon information brochures and questionnaires to 400[1] homeowners in New Jersey. A form for ordering a radon test kit at a reduced price ($ 20) was included. The brochures differed as to their descriptions of risk likelihood and severity and the efficacy of radon mitigation techniques.

It was found that the 19 percent of the sample who ordered the test kit did not differ across the various brochure treatments. Subjective risk estimates and self-reported concerns correlated with ordering test kits and intentions to test. (All respondents were asked about their intentions to test, and all were given the chance to order a test kit). Perceived mitigation difficulty was unrelated to test intentions.

Weinstein, Sandman, and Roberts had predicted that providing homeowners with information about radon risk factors would decrease their concerns and risk estimates[2]. This was found to be true only under the high threat condition, for one of the risk measures (absolute ratings of own risk). The high threat condition involved depicting the radon risk as quite likely and severe. The prediction did not hold for comparative ratings where own risk was compared to community risk.

There was a moderate amount of optimistic bias (i.e., people underestimated the risk) in the radon risk perceptions, as compared

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[1]. The response rate was 68 per cent (271 responded) in this group. The authors do not state how many refused to participate of those who were approached.

[2]. The rationale behind this prediction was that risk information provides material for constructing explanations why they are not at risk. People use it in order to defend themselves against anxiety by means of denial and rationalization.

to ratings of other health hazards on the same scale (Weinstein 1988). This may be a sign of risk denial. Implications of risk denial for risk communication are discussed in section 9.1, page 54.

Although the treatments in which respondents were exposed to high risk messages were partly successful in boosting their beliefs in a high risk level (with the exception noted above), the effects were not strong enough to stimulate an increased level of testing behavior. It is interesting to note that this occurred in spite of a good fit of a model assuming that risk information gives rise to the perception of increased risk which in turn causes protective behavior. The model fitted well, but the effect was weak.

5.6.2. Evaluation

This study is mainly of theoretical interest. For ethical reasons, the risk level communicated cannot vary greatly in practical campaigns, even if it can be depicted in different ways.

As for methodology, the group of subjects was small. No information is given on how many people refused to participate in the study. The reduced price of $20 for a radon test kit seems still to be high, as compared to the price charged in other studies, such as the Maryland study (see Section 5.8, page 35). A lower price may have given a quite different result in terms of the number of people who ordered a test kit. It is not stated why the particular price level was chosen. It is possible, but not documented, that $20 was a reasonably low price for a test kit in New Jersey at the time of the study.

The prediction of a paradoxical decrease of perceived risk with an increase in information was only partly supported. As an after-thought, this may be a type of effect that is secondary to the main effect of risk information, which should be to increase perceived risk and risk awareness, at least up to a point of moderate threat. It is conceivable that a very strong threat may give rise to denial, but such threats are probably uncommon with radon risk.

5.7. Study of effectiveness of communication formats

5.7.1. Design and selected results

The systematic study of effects of varying communication formats in communicating radon risk was begun by the NYSERDA study. That study was concerned with the tone of the verbal contents of the messages and with qualitative versus quantitative risk information.

A study by Weinstein, Sandman and Roberts (1989) deals with the format issue in a very ambitious manner. They investigated two risks: radon and asbestos. Recommended action levels correspond, in these two cases to quite different scientifically estimated risks. The asbestos risk from the action level recommended for schools[1] (3 f/l) is only 1/25 of the risk of 4 pCi/l. The authors chose to present both risks in comparable numbers, i.e. asbestos risk in f/l and radon risk in pCi/l.

Seven different designs of information brochures were tested:

- Probability only (numercial probability of harm)
- Probability plus comparison to smoking risks
- Graphic probability display
- Information about action guideline level only
- Action level, numerical probability and risk comparison
- Action level and detailed action advice
- Action level, probability, risk comparison and advice

All brochures contained an initial 3 pages of detailed descriptions of the risk (radon or asbestos). These formats were evaluated in several measures of communication effectiveness. An experimental design was used. A total of 1948 subjects participated. Of those who were intitally contacted, 34.2% agreed to participate. Of these 67% did respond to the questionnaires, yielding an over-all response rate of 23 percent.

The subjects were given hypothetical risk information about their homes.

There were several interesting findings. Two will be mentioned here. First, information about the action level induced more differentiation among risks as a whole, not only in the neighborhood of the action level (some discontinuity could be discerned around that level). Information about the action guideline only was the condition giving rise to the highest level of perceived risk and most concern. The authors point out that this condition was the only one lacking a risk ladder or a graphical probability display. The subjects had no way of knowing if a value below or above the action guideline was little or much different from it. A ladder gives strong cues as to the difference between an obtained radon or asbestos reading and the action guideline.

Second, the condition giving most information came out as the most effective format. There was no evidence of information

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[1]. There is no official action level for asbestos in homes. Perhaps that is part of the reason why radon risk seems to be more socially acceptable than asbestos risk. Radon risk for schools might be more comparable to asbestos risk action level as here defined.

overload. This condition contained numerical risk probabilities, risk comparisons (smoking), action guideline and advice.

The action level only condition thus appears to be especially effective in alerting people to a risk, while the most informative formats are good at eliciting realistic risk estimates, i.e. alerting some people and reassuring others, depending on their risk readings.

Third, radon and asbestos risks were rated as approximately equivalent in all conditions, despite the true 1-25 range, which was of course communicated both in risk probabilities and in comparison risk estimates. The authors suggest that the reason is the strong cues provided by the exposure ladder. The ladder covered a whole page for both radon and asbestos risks. A smaller ladder for asbestos, appropriate for the lower level of risk, might give a different result. On the other hand, the condition that gave only the action level also did not differentiate between asbestos and radon, perhaps because there was no information about the varying risk levels in that case.

The problem seems to one of using graphics for conveying absolute risk levels, not only relative ones (Cleveland & McGill, 1984; Tufte, 1983).

5.7.2. Evaluation

The study, together with the NYSERDA study, is a good start towards systematic investigation of the effectiveness of risk presentation formats. As the authors point out, there is almost no previous research on the topic - in spite of the existence of several manuals on risk communication.

The response rate of this study was low. This means that the results cannot be safely generalized. On the other hand, the authors state that the response rate did not vary systematically across conditions so the differences between conditions cannot be due to differential response rate.

People who had actually tested their homes for asbestos or radon were systematically assigned to the condition of the risk they had not tested for. It is not stated how many these people were, but presumably they were few. Otherwise, the policy might have created some systematic biases.

The hypothetical nature of the risks presented here constitutes a problem. It is possible that the paradoxical lack of a difference between radon and asbestos risks may be due to a low level of motivation for the subjects who knew that they were not actually exposed to those risks.

Work on risk presentation formats might profit from a contact with psychological scaling research where it has long been known that "absolute" judgments always are affected by context (Parducci & Perrett, 1971).

5.8. Maryland study

5.8.1. Design and selected results

The study evaluates an attempt to inform people about radon risks (Desvousges, Smith & Rink, 1988, see also U.S. Environmental Protection Agency, 1988 a). Three communities in Maryland were involved: Frederick, Hagerstown and Randallstown. These communities were chosen because they had elevated radon levels, a high percentage of owner-occupied, single-family homes and separate media markets. Residents of Frederick received the most extensive treatment: media (radio and local newspapers) information plus a community program. The media program was organized around the theme "Test now and be sure"[1]. This theme consisted of the following parts:

- Radon is a serious health risk: You may be at risk
- Radon testing is easy/inexpensive
- Radon problems can be fixed
- The State of Maryland has a toll-free number to provide testing and mitigation information

The community program involved presentations to community organizations, the placement of posters and brochures in public places and a radon awareness week.

Residents of Hagerstown received the media program only while residents of Randallstown constituted a comparison group used to approximate a control group. In addition, residents of Hagerstown and Frederick received a utility bill insert that reinforced the media theme.

A local television channel, WJLA, carried out a radon campaign which coincided in time with the efforts of the study, leading to a rather difficult methodological problem of separating effects of the television campaign from those of the intervention.

In all three communities there were two samples of participants: a panel sample and a random sample interviewed only after the intervention. The subjects were approached in telephone interviews. The first wave of data was collected in December 1987. Followup data were collected in April 1988.

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[1]. On the basis of the NYSERDA study, messages were phrased more in a command than in a cajole tone.

The findings were that

- There was a high awareness of radon, possibly increased by the WJLA campaign.

- Testing for radon increased only under the most heavy intervention (Frederick), roughly from 5 to 15 percent, mainly due to the intervention.

- Mass media intervention tended mainly to make people "procrastinators", i.e. they now acknowledged the problem but had not gotten around to doing something about it.

- Knowledge of radon increased (and was the only variable showing sensitization effects in the panel samples), especially when it came to general, non-specific questions.

5.8.2. Evaluation

This is a sequel to the NYSERDA study in the sense that the information material was designed on the basis of the results in the previous project. It is a major attempt at risk communication.

The economic constraints precluded extensive use of television, but it is likely, on the basis of much previous research on public service broadcasts, that the results would have been meager anyway (McGuire, 1985). It is well known that public service campaigns on television, aiming at inducing healthy habits, usually have only marginal success.

The researchers concluded that the WJLA campaign had probably only marginal effects on testing for radon. That statement was based on data analysis which attempted to single out the WJLA effects and measure them separately from any effects of their own interventions. It is a bit strange that the official EPA report of the same study (United States Environmental Protection Agency, 1988 a) states that "WJLA's campaign was particularly effective in increasing knowledge, awareness and testing" (p. 31). It is unclear what on what the grounds for this statement are. The researchers reported (Desvousges, Smith & Rink, 1989) that WJLA effects were most clear for awareness, doubtful for knowledge and that "there was no measured effect of the WJLA campaign on testing decisions" (p. 8-14). Since the official EPA document and its assertion about large effects of the WJLA campaign fails to report any supporting evidence the researchers seem to be arguing more strongly for their standing on this issue. The WJLA effects were small. This conclusion is also in line with a large amount of previous work on TV campaigns, see above.

5.9. Florida risk attitudes study

5.9.1. Design and selected results

This is a study of people living in Florida's three "hot spot" counties: Polk, Hillsborough and Alachua[1] (Valenti & Ferguson, 1987). Phosphate mining is extensive in Polk, there is some in Hillsborough and virtually none in Alachua. Phosphate mining is associated with elevated radon levels.

A sample of 837 homeowners were interviewed by telephone. Homeowners with no telephone or with unlisted numbers were not sampled, which excluded about 30 percent of the residents. Interviews were completed with about 40 percent of the remaining sample. About 60 percent of the respondents were female. The data were collected in the fall of 1987.

76 percent of the sample were aware of radon, males having heard of radon more often than females. Even though many people had heard of radon, most of them did not feel they knew much about it. They said they wanted more information, but did little to obtain such information. What they wanted to know was how to test, how to mitigate, what level is safe and where levels are highest.

Valenti and Ferguson point out that while people relied on mass media for information, these media did not have a very high credibility. The media create awareness, but not necessarily concern, and concern is necessary for testing.

It was found that higher concern leads to more blame attributed to the government and puts less responsibility on the individual. Higher awareness, on the other hand, was correlated with greater perceived responsibility on the part of the homeowner. The question is whether it is possible to increase awareness without, at the same time, generating increased concern.

Polk homeowners were most likely to say there might be elevated levels of radon in their county. At the same time they were most likely to deny that there might be elevated levels in their own homes! Males and older respondents were most likely to deny personal risks.

About 48 percent said they were very or somewhat concerned about the effects of radon. Less educated respondents were more concerned, females more than males, younger more than older. This matches the pattern of risk denial rather well. Those who were very concerned were more likely to say they would test for radon, even if a test would lead to a drop in market value of their house.

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[1]. In each of these counties at least one home had measured 8 pCi/l or more.

However, only 3 percent had tested their homes for radon. Some percent of those who had tested said they had taken action reduce radon levels in their homes.

The subjects were also asked about responsibility for radon. Those living in Polk were, as could have been expected, most likely to blame the phosphate industry, but the most common answer was "nature" or "nobody". Those who were less concerned were more likely to blame nature or nobody. In Alachua, the most common answer about mitigation was that the homeowner should pay, while it was more common in Polk and Hillsborough to state that the government should pay. Few seemed to require that the phosphate mining industry should pay.

The respondents were asked about their confidence in various potential sources of information about radon. High ratings were given to the University of Florida scientists, the EPA, the National Centers for Disease Control, and the American Cancer Society. Low ratings were given to the Florida Phosphate Council and "a company selling radon test kits". Compared with male respondents, females had more trust in medical sources and media. More concerned people had more trust in medical sources, in the media and in experts. More concerned people also said more often they wanted more information about radon.

5.9.2. Evaluation

This study is relatively ambitious but has some flaws, especially in the low response rate. The variable of concern is given a somewhat confusing treatment. It is seen as necessary for testing, on the one hand, and as detrimental because high concern leads to blaming others, on the other.

There may be a nonlinear relationship between concern and testing, with very high levels of concern being associated with a decreasing tendency to test. Perhaps a high level of concern is associated with a high probability of testing and a tendency to blame others for the radon risks. At any rate, the concern variable needs to be further analyzed, both theoretically and empirically. The statistical analysis in this study was not carried very far and it is likely that more credible results could have been achieved with more ambitious analysis.

5.10. Florida personality study

5.10.1. Design and selected results

Ferguson, Valenti and Melwani (1988), building on Zuckerman's work on sensation seeking, constructed a personality questionnaire for measuring three dimensions: adventurousness, impulsiveness and rebelliousness. These dimensions resemble Zuckerman's (1988) fo

factors of sensation seeking: thrill and adventure seeking, experience seeking, disinhibition and boredom susceptibility.

Ferguson, Valenti and Melwani found some correlations between their personality dimensions and media preferences for getting information about health hazards. Reliance on television correlated positively with impulsiveness, while rejection of newspapers correlated with the other two dimensions. Their scales were correlated with health attitude, a measure of concern for one's own health, and with a low level of concern over food irradiation and air pollution risks.

The survey also measured the Health Locus of Control (Wallston, Wallston, Kaplan & Maides, 1976). Persons scoring high on this index would be expected to exhibit more concern and more responsibility for their own health. There were some rather weak correlations between this scale and the Ferguson & Valenti scales.

Ferguson and Valenti (1988) used the three dimensions of adventurousness, impulsiveness and rebelliousness to measure risk aversion. They hypothesized that more risk averse people would rate risks as larger and that they would be especially likely to show concern if risks were said to be threatening their children, and if they were not presented with specific steps to take in order to mitigate or avoid the risk, and if the risk is presented together with a simple fear arousing schema rather than in the context of other risks.

They recruited persons who participated in their telephone survey (see Section 5.9, page 37) and 706 out of a total 837 agreed to participate in a panel. They were mailed booklets including radon messages. These messages varied as to alleged source (newspaper vs government brochure), whether children were specifically singled out as being at risk, whether the radon risk was associated with nuclear power (simple, fear-arousing) or with smoking and X-rays (more elaborated cognitive structure), and finally how specific and available were the steps to test for radon. About 320 persons responded (38 percent). The researchers found high risk ratings when the more complex comparison schema was activated (i.e. smoking and X-rays) <u>in a newspaper context</u>. They found high fear ratings when children were targeted, with a complex comparison schema, regardless of context. More information about radon was requested when the target was an adult rather than a child, especially if the source was depicted as a government brochure. People who were risk averse requested more information when the source was a newspaper message with low specificity. There were some further interactions between personality and the message variables, partly different for men and women, but these findings only partly confirmed the hypotheses. They were complex and seem to need replication.

5.10.2. Evaluation

This work is of interest mostly because it is one of the very few attempts to relate personality variables to attitudes to radon risks. The response rate was rather low and the variables seem of doubtful value since they are based on very few items. The findings were suggestive at best, and need replication. There were many complex results, some of which may be due to sampling and measurement errors.

5.11. Onondaga study

5.11.1. Design and selected results

Mazur and Hall (no date) conducted a study of 204 single family dwellings in Onondaga county, New York. Radon data were obtained during the 1986-87 heating season. The homes had been selected because there were suspicions of high radon levels. These suspicions were confirmed, median readings being 5.1 pCi/l and 4.6 pCi/l, for basement and living areas, respectively. 52 percent of the living area readings were above the EPA action level of 4 pCi/l.

They found that specific concern about radon, related to the respondent himself, was correlated[1] with information search a mitigation, while general concern (concern without specif reference to the respondent himself or his home) did not correlate with mitigation. Specific concern was correlated with radon readings (about 0.5) but not with family or media influence, which however correlated with general concern.

5.11.2. Evaluation

This study was of limited scope but it did introduce an interesting distinction between personal and general concern. It is possible that personal concern can be expected to be stronger for radon risks than for many other risks since, according to Weinstein, denial of such risks is relatively weak. That may be the reason why Mazur and Hall found that specific concern was strongly related to technical risk. On the other hand, the finding is puzzling since other researchers have failed to find any relationship.

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[1] Some of these correlations were remarkably high, such as a 0.76 correlation between specific concern and the intention t mitigate.

6. Empirical studies of mitigation

6.1. Introduction to mitigation research

Even if people test for radon and find that their house has a high level of the gas, there is no guarantee that they actually do something about that condition. Therefore, special studies of mitigation are needed. Very few such studies have been published so far.

The problem of mitigation and risk perception is a special case of the problem of the relationship between attitudes and behavior. People have been found in many studies to behave quite differently from what they say they will do or what they prefer (Wicker, 1969). Indeed, Wicker reviewed data showing very weak relationships between general attitudes and specific behavioral measures. On the other hand, Fishbein and Ajzen showed quite convincingly that there is a strong relationship between attitudes and behavior whenever attitudes are measured at the same level of specificity as the behavior. In other words, if a specific protective behavior is to be predicted from an attitude measure, that measure should be equally specific.

6.2. Maine study

The first reports on the relationship between mitigation and radon readings have been disappointing (Johnson & Luken, 1987; Weinstein, Sandman & Klotz, 1987). People with a higher objective risk level were not more likely to mitigate.

According to Weinstein, Klotz and Sandman (1988) "People are seldom willing to take preventive measures unless convinced that their own risk is significant and that risks would be serious" (p. 796).

6.3. New Jersey study

One of the first major attempts to study mitigation of radon problems was reported by Weinstein, Sandman, and Roberts (1988). They followed 123 New Jersey homeowners who had discovered at least two years previously (in 1986) that they had a radon problem, i. e., a level exceeding 4pCi/l. The percentages of people in each exposure category who did at least some mitigation[1] is shown in Table III.

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[1]. Some physical changes were required in order to qualify for the mitigation category. Behavioral changes, such as more frequent opening of windows, did not count.

Table III. Percentage of persons who had mitigated as a function of their first floor radon reading. Data from Weinstein, Sandman and Roberts (1988).

First floor reading (pCi/l)	Percentage who mitigated
> 20	93
8-20	71
4-8	62
< 4	45

Note that nearly half in the group below the official action level actually did carry out some mitigation.

Few people retested after mitigation. (A retest is important because there is no guarantee that the actions taken actually will reduce the radon level). A third of those who had done some modifications did not retest, and none of those who relied on behavioral methods (such as opening windows frequently) had retested.

Of those who had retested their homes following mitigation 9[illegible] percent said modifications were successful. There was an averag[illegible] drop from 15.2 to 2.0 pCi/l. (First-floor level). Basement readings dropped from an average of 37.3 to 3.9.

Weinstein, Sandman, and Roberts estimated that radon remediation saved between 8 and 13 lives for every 100 households in the confirmatory monitoring program with ratings of experience and frequency) and personal experience.[1] About 30 percent of the lives saved were estimated in homes with initial radon levels below 20 pCi/l. These estimates should be taken with a grain of salt, of course, since they are based on a small sample and since these people were atypical in being among the first to test and mitigate.

The best predictor of mitigation was not the actual radon level measured but how serious people felt it to be. Other significant predictors of action were perceived likelihood of health problems, of effects of radon on home property value, distress due to worry over the radon risk, and perceived personal susceptibility. The dominant reason for <u>not</u> acting was that the homeowner did not believe that the risk was very serious. The most

[1]. Several assumptions were behind these figures, of course. Perhaps the most crucial assumptions were (a) that people would be exposed to the measured radon level for a lifetime, and (b) that mortality is a linear function of the radon level, starting with 2 lung cancer cases per 100 persons for a level of 4 pCi/l.

frequently mentioned difficulty of mitigation was getting information about how radon levels could be reduced.

The authors point out that the group may be atypical since they had shown their concern by confirmatory retesting and also by agreeing to take part in the follow up study.

6.4. Washington study

The most extensive study of mitigation so far was performed by Doyle et al. (1989). They mailed a questionnaire to 920 homeowners in the Washington, D. C., area who had tested their homes for radon. The tests had been performed in the beginning of 1988 in response to an extensive television campaign on the WJLA channel. Test kits had been made available at a reduced price[1] at local Safeway stores and through a newspaper advertisement. A total of 116,000 kits were sold, by no means exhausting the demand. A testing firm named Air Check had analyzed the kits that were submitted to them and had reported back to the homeowners about their radon levels[2].

The test results from Air Check were sent together with some additional information. Homeowners were told that no mitigation should be undertaken unless a second test also showed an elevated radon level. Those with radon levels exceeding 4 pCi/l were advised to perform a second test. Those with radon levels between 4 and 20 pCi/l were sent a somewhat revised version of EPA's booklet "A Citizen's Guide to Radon", while those with levels higher than 50 pCi/l received EPA's booklet "Radon Reduction Methods" and a free test kit for a re-test.

Stratified sampling was employed, i.e. an equal number of homeowners was sampled for the four radon levels <4 pCi/l, 4-20 pCi/l, 20-50 pCi/l and >50 pCi/l. The 77 percent response rate was quite good. The data were collected in December 1988.

In spite of the strong recommendation to perform a second follow-up test, over 85 percent of the respondents had not done so. (Due to the design of the study, about 75 percent of the total sample had obtained radon levels exceeding 4 pCi/l).

The results on mitigation are given in Table IV. In this table, mitigation refers to any kind of action taken by the respondents, i.e. including simple behavior changes such as leaving windows open more frequently. Opening doors and windows more

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[1]. The price was reduced to about half the regular level.

[2]. About 56,000 of the 116,000 that were sold.

frequently was, in fact, by far the most common mitigat[redacted] activity.

Table IV. Percentage of persons who had mitigated as a function of their radon reading. Data from Doyle et al. (1989).

Radon level (pCi/l)	Percentage who mitigated
> 50	49
20-50	42
4-20	14
< 4	3

These figures are considerably lower than those reported by Weinstein, Sandman and Roberts (1988), see Table III. However, the latter data refer mitigation likelihood to first floor readings, while Doyle et al. did not analyze their data for differen[redacted] responses contingent on where in the house the test kit had be[redacted] placed. The data obtained by Doyle et al. suggest that most tes[redacted] results refer to basement readings. It is natural to expect more concern about a first floor reading than about the same reading from the basement.

Still, the differences between the two data sets are so extensive that it appears likely that other factors also have affected the samples differently. Most important, the Weinstein et al. sample consisted of highly motivated people who were among the first to test their homes, and they were followed for a longer time[1] than the Washington group, which was probably more typical in their level of involvement in the issue of radon risk.

Doyle et al. also reported that the reasons homeowners gave for mitigating their homes were predominantly health related, very few referred to economic value and homesale consequences. Of course, few may have been considering selling their homes at this particular point in time (homes are sold after 10 years of residence, as a national US average).

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[1]. The time factor may have been unimportant. Less than 1 per[redacted] cent of the respondents in the Washington study said they planne[redacted] mitigation in the future.

Doyle et al. estimated the effects of the WJLA campaign in terms of how large a share of the population of homes in need of mitigation was actually mitigated in a "credible" manner. The results were about 0.1 percent for houses with a level between 4 and 20 pCi/l, 0.5 percent for those above. About half of the test kits were returned for analysis, and some kind of mitigation was performed in slightly less than 50 percent of the cases where the level exceeded 20 pCi/l. However, only about 30 percent of mitigation went beyond habit changes such as leaving windows open more frequently. In addition, those with radon levels between 4 and 20 pCi/l were much less likely to mitigate, and that group is, of course, the major "problem" group since there are so many more homes in this group, even if those with higher readings constitute a larger risk for the individuals concerned.

Summing up, the net result in terms of credible mitigation was meager. There were two major reasons for this finding:

(1) Few people bought test kits, only about 6.5 percent.

(2) Only a minority mitigated. The percentage of homes mitigated was especially low for radon levels between 4 and 20 pCi/l.

Doyle et al. conclude that "the likely credible mitigation resulting from the program has been so small as to suggest that such programs may be a very expensive way for society to achieve mitigation" (1989, pp. 164-165).

6.5. Colorado study of testing and mitigation at time of home sale

This is a study by Doyle et al. (1989) of recent home buyers. The purpose was to determine how common testing is at the time of buying and whether such testing leads to mitigation. The authors also report some information about common practices among realtors in several States. Their own data were obtained in Boulder, Colorado. There had been no prior extensive attempts to inform the public about radon in that state.

Doyle et al. reported the results of a telephone survey of 100 home buyers in Boulder. They had to approach 210 buyers in order to get 100 interviews, so the response rate was slightly less than 50 percent. The houses had been bought in the fall of 1988 and the interviews were made in December of that year.

The number who had tested for radon in connection with the sale was 43, most before the sale closed. Of those who had tested for radon, 8 reported some kind of mitigation and 5 of those had retested to check the outcome. Of the 8 mitigators, 7 had had close contact either with an employer (IBM) who strongly supported radon testing and mitigation, or with a realtor or a contractor who provided expertise in the area.

Doyle et al. pointed out that the overall mitigation rate [redacted] this group was about 15 percent, to be compared with the 0.1 percent obtained in the Washington study. (Data refer in both cases to those homes that had radon levels > 4 pCi/l). Thus, the effectiveness for stimulating radon testing and mitigation of buying a house was about 150 times as great as that of a major media campaign.

6.6. Some Swedish experience: the Sollentuna study

Concern about radon started earlier in Sweden than in the USA. Alum shale was frequently employed as a building material before 1975, and the initial concern was with radon emitted by building material. Subsequently, geological radon has come into focus. The National Institute of Radiation Protection has estimated that radon causes about 1100 lung cancer cases in Sweden yearly (in a population of 8.5 million). The figure is much higher per capita than the corresponding American estimate of a maximum of 20 000 cases per year. This is somewhat puzzling, since data indicate that the home radon levels are probably somewhat higher in the USA than in Sweden, see page 12, Table I.

The action level recommended by the Institute is 10 pCi/l[1], in other words 2.5 times that of the EPA. It is unclear why Swedish authorities are so much more prone to accept radon risks. Th[redacted] Swedish action level corresponds to the lung cancer risk of smokin[redacted] a pack of cigarettes per day[2].

Local authorities inform home owners that this level involves an elevated risk of lung cancer. The local authorities are responsible for dealing with radon risks, but their policies vary greatly. Swedes are just as indifferent to mitigating their homes for radon as are Americans (Johnson, 1987).

Åkerman (1988) reported a study of mitigation and willingness to pay for mitigation in Sollentuna, a suburb north of Stockholm. Radon had received considerable attention in this town. Home owners could have the local health department conduct a test and the cost was 400 SEK, about $65. If the result was above 10 pCi/l the health department offered a free retest and provided mitigation advice.

Åkerman obtained extensive data from a sample of 317 homes that had been tested with results above 10 pCi/l. The estimated WTP

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[1]. In Sweden the scale used is that of Bq/m^3. The conversion formula is 1 pCi/l = 40 Bq/m^3.

[2]. However, a recent decision states that the maximum allowe[redacted] concentration in new construction is 2 pCi/l.

in 1986 prices (yearly cost) was 3120 SEK ($510), or 918 SEK ($150) per person since there were on the average 3.4 persons per household.

The data in this study were obtained from archives. There was no information about actual mitigation costs, but experts estimated the generic costs on the basis of detailed information about radon readings and technical characteristics of houses.

The implied WTP of these data was $0.35 for reducing exposure by 1 Bq/m^3 per person, or $13 for a reduction of 1 pCi/l. The general policy of the National Institute of Radiation Protection is that one should be willing to pay 43.50 SEK per annum for a reduction of 1 Bq/m^3 ($88.50 for 1 pCi/l), roughly 6 times as much. It is possible that this difference reflects the often noticed difference between individual and collective risk taking. Collectively taken risks are accepted only at a level an order of magnitude less than that accepted for individually taken risks (e.g. Sjöberg & Winroth, 1986). Åkerman, Bergman & Johnson (no date) argue that the estimates are understatements of the true WTP values since (a) all costs could not be taken into account, and (b) it is unknown what risk perceptions the homeowners actually had, but likely that they perceived smaller risks than the expert risk judgments on which the calculations were based. As the authors stressed, further work on WTP should make use of individuals' risk judgments rather than expert estimates. The problem that will then arise is, of course, that unbiased risk judgments are very difficult to get.

WTP methods can be discussed. Do people really give realistic estimates of their willingness to pay? Dicke, Fisher and Gerking (1987) compared actual purchases (of strawberries) with stated willingness to buy. They found rather good correspondence between the two sets of data. However, we still do not know how realistic such estimates are in different settings and with more important choices, such as those involving health risks. It may be that people are less likely to give such ratings in an unbiased manner. Strategic considerations may easily enter.

Åkerman initially found only a weak correlation between mitigation cost and initial radon reading. This result is in line with some American data, perhaps most clearly the Maine study. However, after controlling for several independent variables, most notably kind of ventilation[1], she found a clear relationship between WTP and probability of mitigation and initial radon reading, see Table V for the latter relationship.

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[1]. Three types were distinguished: passive ventilation, forced-air exhaust ventilation and forced-air intake and exhaust ventilation.

Table V. Percentage of persons who had mitigated as a function of the initial radon reading. Data from Åkerman (1988).

Radon level (pCi/l)	Percentage who mitigated
12.5	38
25.0	50
37.5	57
50.0	62
62.5	65
75.0	68
87.5	70

Bergman, Söderqvist and Åkerman (1988) also reported a study of sales prices as a function of radon. They did not find any significant influence of radon on price level, confirming the impressions by American realtors reported by Doyle et al. (1989). However, Bergman et al. also pointed out that the tax assessment of houses had been lowered whenever there was an elevated radon reading, leading to a somewhat smaller tax. The tax "discount" could have been enough to compensate for the presence of radon risk.

Some of the Swedish results are different from American data. The overall picture in Åkerman's study was one of a certain degree of rationality. The reason could be, of course, that her WTP data were based not on homeowners' actual investment in protective behavior, but in experts' estimates of generic costs. Presumably, experts are more rational than people in general. The reason could also be that Swedes, especially those in places where radon has been intensely discussed, such as Sollentuna, are more knowledgeable than Americans about radon, or that they have access to better advice. Finally, the reason could be the smaller income variation in Sweden, which decreases the confounding effects of how much money people can afford to spend on mitigation. Also, state subsidized loans are available to homeowners in Sweden for radon mitigation, and even ordinary bank loans may be cheaper than in the U.S. because interest is deductible up to 50 percent.

It should be added that rationality is not overwhelming in Åkerman's data. 30 percent are estimated to ignore mitigation with an exposure level of 87.5 pCi/l. At this level, the estimated added risk of lung cancer approaches 1/2, corresponding to about 10 packs of cigarettes per day for every family member, including children. Willingness to pay data imply an implicit life value of some $6000 per family member at this level of exposure, a small fraction of official figures both in Sweden and the USA.

The estimated over-all implied life value, according to Åkerman, Bergman & Johnson (no date), was only about $100 000. This compares unfavorably with the range $2 million to $7 million per statistical life save reported for American data (Fisher, Chestnut & Violette, 1988).

The reason could be the above mentioned risk denial that was probably present, or it could be that people do not believe that a reduction of radon below the action level (10 pCi/l) has any positive health effects. The Swedish information material does not mention that a further reduction is of any value.

A further possibility, not mentioned by the authors, is that human life simply is less valued, at least in monetary terms, in Sweden than in the USA. Damage compensation awarded by Swedish courts for loss of life or various types of smaller damages tend to be 1-3 orders of magnitude smaller than the American corresponding figures. It seems, however, that comparisons of countries are quite complicated because Swedish authorities are likely to react to prevent damage, even if they do not feel that individuals should be compensated financially to any great extent once damage has occurred.

6.7. Evaluation and conclusions of mitigation studies

A major factor in mitigation is, of course, the measured radon concentration level of a home. The three studies of mitigation discussed above all produced some quantitative information about mitigation frequency as a function of radon concentration. They are plotted in the same graph[1] in Figure 2 [2].

It can be seen that the data from the study by Weinstein et al. deviate from the two other data sets in yielding much higher levels of mitigation. As pointed out above (see page 44) the values obtained in the New Jersey study refer to living room readings and may therefore be misleadingly high. In addition, that study involved a group of people who were probably unusually strongly motivated.

Research on mitigation has so far not been very extensive and most of the experience is very recent. However, some observations can

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[1]. ♦=data from Weinstein et al., ▲=data from Doyle et al., •=data from Åkerman et al.

[2]. In the plot of Figure 2 the minimum and maximum levels of radon concentration for the two sets of American data were estimated by adding or subtracting 20% from the stated lower or upper limit, respectively.

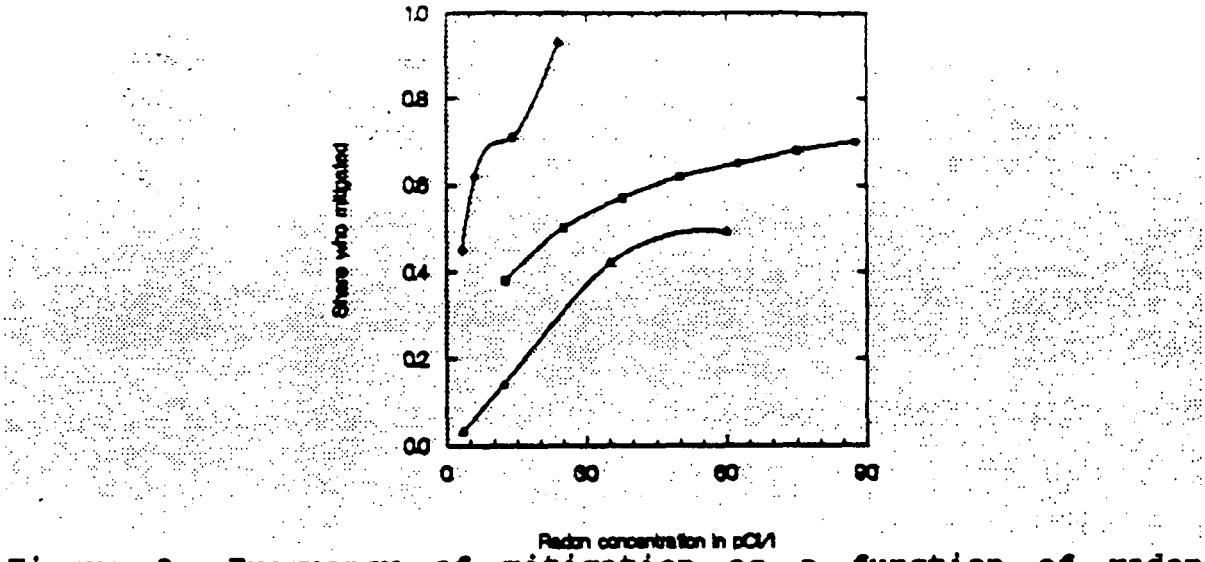

Figure 2. Frequency of mitigation as a function of radon concentration.

be made.

(1). Given that people have tested and found an excess level of radon it is reasonably likely that if they they are going to mitigate, they do it within one year. No data support the assumption that they may delay mitigation longer than that.

(2) The probability of mitigation has in almost all studies been found to be an increasing function of initial radon reading.

(3) In a few studies there has been an obscure raw data relationship between initial radon reading and mitigation behavior. The reasons could be (a) technical characteristics of houses, perhaps in particular type of ventilation system, (b) the income variation in the sample, (c) availability of expert advice and (d) variability of risk preferences.

(4) People seemed less likely to re-test to find out if their mitigation had been effective, with the possible exception of those who had just bought a house, or were in the process of buying one.

(5) The net effect of media campaigns on the number of people who mitigate is probably quite small. The effect of encouraging realtors or employers at the time of buying a house seemed in one small-scale study to be 100-200 times larger.

7. Comments on empirical studies of radon risk perception and mitigation

Early concern that people would panic over radon has clearly been found to be unsupported. The opposite is true: people are too little concerned about radon risk.

There have been three major attempts to investigate risk perception and testing decisions: the NYSERDA, Maryland and New Jersey studies. Studies of mitigation have so far been few, and more such studies are needed; some are under way.

The most successful variables in predicting testing found so far are those that measure (a) personal risk perception and (b) social influence. Personality variables have not been found to be very important when it comes to the perception of radon risk or testing decisions.

The most common problem in these studies has been that of representativeness of the sample studied. Probably because the problem is so new and research resources have been limited there have been few attempts to test variations of messages in communication studies. It seems, however, that simple and straightforward messages are to be preferred. Messages that are too simple can be detrimental if the purpose is to reassure people that the risk is negligible. On the other hand, the most common problem is the opposite one: how to motivate people to test and mitigate if appropriate. Therefore, it is possible that one should consider quite brief and simple messages.

Are people at all rational when it comes to the perception of radon risks? Psychologists have tended to emphasize that, in general, people perceive risks incorrectly. Depending on circumstances, they may exaggerate or understate risks. However, in the Maine and, in particular, the NYSERDA studies it was found that people revised their risk estimates in accordance with the information that they received.

This finding is not inconsistent with a general skepticism about people's subjective risk perceptions. In the cited studies, there was still virtually zero correlation between subjective risk and measured home pCi/l level. Maybe people have such a distorted view of risks partly because they seldom get clear information and feedback about risk levels. The finding that they would revise their risk estimates in a correct direction suggests that they can treat risk information in a correct manner. The problem may simply be that they seldom receive such information.

8. Predicting monitoring for radon

Some of the studies treated above investigated the tendency of people to monitor for radon. It is a potentially important issue to determine whether it is possible to predict who is most likely to test. However, the problem is difficult to investigate because so few people have tested, less than 4 percent in the population. A statistical analysis is not meaningful if the number of testers is so few as, e.g., in the Florida study (Section 5.9, page 37).

Weinstein finds the following predictors of the intention to test:

- believing that radon is a personal risk
- believing that others are concerned about radon
- a feeling of distress caused by worry over the radon risk
- having more children
- being better educated
- having lived fewer years in home
- being a nonsmoker

Weinstein also found that several factors were not predictive of testing intentions:

- knowledge about radon
- perceived effect of radon on home values
- perceived cost of remediation
- perceived severity of risk
- perceived efficacy of mitigation

Note especially the last two factors which should have been efficient according to models of protective behavior, such as the Health Belief Model (Becker, 1974).

Those who had never thought about testing knew less about radon. They were quite different from the ones who had thought about the issue and found it unnecessary to test.

Further analyses of testing behavior were reported in the EPA Interim Report on the Radon Risk Communication Project (U.S. Environmental Protection Agency, 1987 b). These results were derived from the New Jersey data collected by Weinstein and co-workers and from a University of Pittsburgh study of people who had purchased test kits (N=70,000) or been provided with such kits at no cost (N=3,500).

Major findings from New Jersey data, in addition to those already stated, were that

- Testers were affluent and middle-aged.

- People who planned to move within the next two years were more likely to test for radon.

- Households in which someone usually sleeps in the basement were more likely to test.

- Households with children under 10 were slightly more likely to test.

Findings based on the University of Pittsburgh study were that

- States that contained radon "hot spots" had more testers, as compared with states that had no such hot spots.

- People who suspected elevated levels before testing tended to be right.

The Maryland study (Section 5.8, page 35) reported only three significant predictors of spontaneous monitoring:

- Level of knowledge about radon[1].

- Whether people asked their physician a lot of questions about their health.

- Educational level.

In conclusion, the following factors have been documented as being of some importance for the testing decision:

- Demographic characteristics: young or middle-aged people, and parents, tend to be more inclined to test.

- Nonsmokers are slightly more inclined to test than smokers.

- The perception of a risk as personal rather than general is associated with testing.

- The perception that others are concerned about testing is associated with testing.

- A feeling of distress over the radon risks is associated with testing.

- General health concern

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[1]. The causal direction here is debatable. Other data show that people do not become more likely to monitor if they get more information. Possibly, the process of monitoring by itself involves learning about radon.

These findings suggest that risk communication should str[redacted] personal risks and that social diffusion processes should [redacted] employed, whenever possible.

9. Factors affecting risk perception

Few people seem to be concerned enough about radon risks to test their homes and to mitigate. One of the most important variables responsible for this indifference is the perceived risk, which is low. Therefore, an analysis of risk perception is called for in order to give a background for improved risk communication.

9.1. Risk denial

Risk perception has often been studied within the perspective of cognitive psychology and heuristics (Sjöberg, 1979). This literature is probably less relevant for understanding of radon risk where other factors seem more important.

People tend to be indifferent toward abstract threats to society (Sharlin, 1987), but concerned if threats are oriented towards themselves or significant others. At the same time, there is often denial of risks to oneself, a phenomenon well documented in health psychology (Weinstein, 1980, 1984, 1987).

People deny many health risks, among them the risk from rado[redacted] This is an example of a general trend toward exaggerated optimis[redacted] when it comes to one's own person (Perloff, 1983). Why is there such a tendency? Kunda (1987) suggested that people construct self-serving theories, or evaluate evidence in a self-serving manner, and that this process is motivationally guided. It is relatively easy for most people to come up with ad hoc causal "explanations" for anything, after the fact has occurred (Anderson & Sechler, 1986). At the same time it is increasingly difficult to predict anything on the basis of such construals because people generate such theories even on the basis of a single instance (Anderson, 1983).

Weinstein (1987) investigated several factors that had been suggested as causes of optimistic bias in risk estimation: defensive denial, self-esteem (as reflected in ratings of risk preventability and embarrassment if exposed to risk), cognitive errors (revealed through the correlations of bias with ratings of experience and frequency) and personal experience. The latter concept was measured by responses to the statement: "If you haven't had this problem by the time you're my age, it's not likely to happen to you".

Weinstein obtained data from a random sample of 296 New Jersey residents (survey response rate 68 percent). They rated 32

different health hazards, making comparative risk judgments[1]. They also rated the hazards in several other respects.

There was no evidence of defensive denial. The strongest determinant of optimistic bias seemed to be personal experience. Variables related to self-esteem were important and cognitive errors seemed to enter as well. Optimistic bias was largely unrelated to background factors such as age, gender, race and education.

Weinstein stressed that if people believed that there was the slightest chance that their characteristics (lack of certain risk factors) might enhance their chances of avoiding disaster, they took full advantage of the opportunity to create optimistic beliefs. In doing so, they utilized specific factors that were characteristic of their situation. To counteract optimistic bias it will therefore be necessary to individualize the general knowledge that people have about a risk, and at the same time avoid the influence of individualized wishful thinking.

Weinstein, Sandman & Klotz (1988) argued that radon risk differs from many other health risks because it (a) does not threaten self esteem, and (b) is hard to deny on the ground that the risk is low because no symptoms have yet been observed. (Lung cancer does not occur until late in life anyway, so the argument would be inconsistent with medical science). However, these arguments have not been tested empirically. Even if an owner who bought his or her house before 1984 cannot, logically speaking, be blamed for having a house with an elevated level of radon, it is still quite possible that the owner blames him- or herself. Moreover, despite medical science, people may argue that "I have lived in this house for 30 years and I have not developed lung cancer so I don't believe there is a risk" as a reason to justify lack of action. Weinstein found that such reasoning was the strongest determinant of optimistic bias.

Weinstein also found clear evidence of risk denial. This was apparent in several of his variables. For example, only 6 percent of those who had an opinion said their radon level was likely to be more or much more than the average in their community. Optimistic bias was evident in the overall reasoning of the subjects, who used their knowledge about radon to construct

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[1]. The format of the rating scale was: "Compared to other men/women my age, my chances of getting the problem in the future are: much below average, below average, ...etc... to much above average". Seven rating categories were used. The responses were scored on a scale from -3 to +3, 0 indicating a rating of average risk. Evidence of optimistic bias was available at the level of group data whenever average ratings were <0. Such was the case for 31 of the 32 health hazards.

optimistic scenarios. Among those who had tested for radon, there was only a very slight correlation between the judged seriousness of the risk and the radon level obtained. A similar finding was reported by Johnson and Luken (1987).

Weinstein et al. proposed that the reason why radon risks are underestimated, while many other environmental hazards (waste disposal, nuclear power, etc) are commonly overestimated by the public, is that nobody can be blamed for radon risks. This is an interesting hypothesis, but so far little has been presented to support it. In addition, it is not clear why nobody should be blamed for the radon risk. One could argue, for example, that planners and realtors should have foreseen the risk and avoided building on sites where radon is likely to be high, or that a homeowner should have taken action to reduce the risk. Maybe that type of blame is unlikely because the risk is so new.

9.2. Diffusion processes

Risk perception has been found to be quite sensitive to social influence such as messages from friends and neighbors. Part of the spread of risk attitudes in a population is therefore dependent upon social diffusion. For social diffusion to work, homeowners must perceive their neighbors to be concerned about radon and they must interact with them about the issue (Unger & Wandersman, 1985). In the New Jersey study, people reported a lack of knowledge about how their neighbors viewed radon risk and a need for such knowledge. Furthermore, if they reported an opinion, they tended to say that they saw their neighbors as little concerned. People who had tested wanted to tell others about it, however, and more often so if they had obtained high radon level test results. But they said their neighbors did not want to listen.

Desvousges, Smith and Rink (1989) found that one of the best predictors of testing for radon was whether a person had talked to someone else about radon. This finding is open to various interpretations. It is plausible that testing itself is the cause of some verbal interaction. On the other hand, other research strongly supports the interpretation that personal interaction among people is conducive to behavior change.

According to Rogers (1987) new precautions are by themselves much less likely to spread through a population than other new ideas, because they entail immediate costs and no immediate benefits. This is in addition to the negative experiences of those people who actually <u>have</u> tried to talk to their neighbors about radon testing; they feel stigmatized.

Diffusion seemed to work in the NJ study, but there was too little "input" for it to spread widely. There were too few people

who had tested for radon, and those who had tested were sometimes discouraged from talking about it with their neighbors.

Mazur and Hall (no date) and Mazur (1981) argued that risk perceptions are especially amenable to social influence when they concern risks that are abstract and not immediately present, while imminent hazards are perceived in a fairly realistic and rational manner. People are influenced, if risks are distant and diffuse, by the opinions their friends have, and by mass media.

9.3. Assimilation-contrast model of risk perception

Sjöberg and Drottz (1988) studied various groups of nuclear power plant personnel and found an inverse U-shaped relationship, across groups, between perceived everyday life risks, e.g. traffic risks, and job risks. The maximum rated general (everyday life) risk level was found for those who had rated their job risk as being of a medium size job risk. For low to medium size risks, the correlation between perceived everyday life risks and job risk was positive, and for medium to high job risks it was negative.

Sjöberg and Drottz suggested that a threat of low to medium strength increases all risk estimates by assimilation (enhanced similarity) while a medium to very strong threat will so dominate a person's perception of risks that other risks appear as small, a contrast effect.

The assimilation part of the model has been supported in other work. Johnson and Fisher (1989) found that when people were informed about radon risks (which happened to be quite low in their sample) their perception of these risks dropped, but so did their ratings of other risks. (The opposite would occur, according to the model, if people were to be re-assured about a risk they had greatly exaggerated).

9.4. Risk posterior to action

There is considerable evidence that risk perceptions correlate with action. It is usually assumed that risk perceptions are prior to and partially cause action. Mazur and Hall (no date) suggested the opposite relationship, i.e. that risk perception is a function of action, or lack of action, and that highly discrepant risk perceptions may serve as justification for lack of appropriate action.

Although this interpretation may at times have some validity it seems unlikely that it would be generally true.

9.5. Objective vs subjective risk

Most risk researchers seem to agree that people's responses to threats and hazards are more determined by their subjective perception of risk than by the objective, or true, level of risk[1]. Mazur and Hall (no date) suggested that this psychological explanation may sometimes be incorrect and that objective risk may directly drive behavior when the risk is imminent and the response specific. With more distant or diffuse hazards and more generalized responses the psychological model would still be expected to hold, according to these authors.

These notions can be debated. First, it is unclear how an objective risk could have an effect on behavior except as a subjective experience. If the objective risk is found to "drive" behavior, this is consonant with a subjective risk that is an accurate reflection of the objective risk. Second, a high degree of correspondence between subjective and objective risk requires freedom from emotional interference with risk perception. Such interference is especially likely whenever the risk is imminent and large. Denial of risk has been found to prevail quite generally, especially for very threatening risks.

Hence, it does not seem likely that objective risks are of direct relevance except possibly when the risks are moderate or small. Information about objective risks have rarely been found to affect people's behavior in published research on the issue.

There is a possibility that the lack of effect of risk information is due to an illusion. First, researchers may be most concerned with problematic cases where people have failed to respond. Second, social concerns about lack of response may arise because a minority of people neglect warnings, while most people do respond in an adequate manner. Lack of response to warnings and even to legislation in even a small minority of people may be a social problem, partly because they may constitute a danger to others (e.g., drunk drivers). Hence, concern about lack of response to risk information may be confused with its prevalence.

It should be added that even if these arguments have some validity in general they do not seem to pertain to radon. Radon is certainly a case where most people have, so far, failed to respond to warnings. Objective risk does not appear to be important in affecting behavior in this area.

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[1] I bypass the often tricky problem of how to define true risk - see Freudenberg's (1988) stimulating discussion.

9.6. Demographic characteristics

Sex differences are commonly found in risk studies. There is no clear evidence that men and women experience different levels of concern when it comes to radon, but some findings suggest that women are more worried over health risks while men are concerned over the economic aspects, such as potential loss of property value. Women seemed to be better informed about radon risks than men (U.S. Environmental Protection Agency, 1987 a). Couples with small children, or expecting a child, seem to be more concerned about radon than others.

Long term residents in an area are usually found to be more skeptical about the necessity of radon testing than those who have lived a shorter time in an area. Of course, those who have lived longer in an area would tend to be older. They might also be more personally involved with their homes and have a longer story of benign exposure to their environment.

There are some weak effects on testing of education and non-smoking, and from having small children.

9.7. Cognitive processing limitations

It has been shown in many studies that people have limited ability to process information (e.g. Anderson, 1985) and that their attitudes tend to be determined by a few salient attributes rather than a complex net of many aspects (Krosnick, 1988).

These findings are somewhat difficult to reconcile with the well-known list of risk dimensions of Slovic, Fischhoff and Lichtenstein (1981). These authors suggested a fairly large number of risk dimensions. On the other hand, Sjöberg and Winroth (1986) investigated the moral dimension of risky actions and found that it accounted for a very sizable proportion of judgments of acceptability of risk. The predominance of morality seems to be in line with general principles of cognitive psychology in the sense that one single factor accounts for a large share of the variance of rated risk acceptability.

9.8. A note on terminology: Hazard and outrage

Sandman, Weinstein and Klotz (1987) introduced a distinction between hazard and outrage. Hazard refers to "risk estimates based on mortality and other 'objective' data" (p. 106), while outrage is based on "subjective" factors. Sandman et al. mentioned especially the factors "fairness, naturalness, familiarity and controllability" (p. 106).

These terms seem to denote much the same as the more comm terms subjective and objective risk. The authors stated that they wanted to replace the traditional terminology in order to avoid encouraging the experts "to see the public as mistaken, misguided, wrong in its subjective risk assessments" (p.106). Although their objective was worthwhile, their choice of new terminology seems less than perfect. According to Webster's Ninth New Collegiate Dictionary (1987) outrage means

(1) An act of violence or brutality.
(2 a) Injury or insult.
(2 b) An act that violates accepted standards of behavior or taste.
(3) The anger and resentment aroused by injury or insult.

The intention to convey less irrationality by switching from the term subjective risk to outrage hence seems not to be well served by the word outrage. In addition, outrage connotes a rather strong, emotionally flavored response. Neither of these components is necessarily true of subjective risk.

10. Risk perception and protective action

One persistent problem is the lack of correspondence between knowledge and attitudes on the one hand and action on the other. People frequently agree that many types of behavior should be avoided, yet find it very unattractive and difficult to do so. Examples are provided by all sorts of addiction. People agree that they should test their homes for radon or change their food habits but delay such rational and health-promoting actions indefinitely. The question is why people act this way.

Sjöberg studied addictive behaviors (smoking, drug addiction, alcohol abuse and excessive eating), in particular relapses in addiction [see Sjöberg (1980, 1985) for reviews of this work]. He found that people who try to live up to a long term commitment, such as sobriety, frequently fail when they are emotionally agitated. Emotional agitation seemed to be equally disruptive when it was negative as when it was positive. The most crucial factor in the regulation of action was the ability to counter-act emotionally induced short-sighted behavior.

This kind of behavior was mediated by cognitive deterioration. People were very good at producing excuses for lapses and virtually never told themselves in a cold and rational manner that they no longer needed to adhere to their commitments.

Although this work is only indirectly relevant to health protective behavior when it comes to radon there may some similarities that make generalizations plausible, at least for some types of behavior that neglect health. The difference is, of course, th

existence of strong positive attraction in the case of addiction. Procrastination seemed to be a dominant behavior pattern in the Maryland study (see Section 5.8, page 35), and procrastination is a typical form of irrationality (Silver & Sabini, 1981).

Weinstein (1988) suggested a model of stages of health-protective behavior. He contrasted this stage-oriented, dynamic approach with traditional decision-oriented models. Models such as the health belief model (Becker, 1974) and variants, such as Fishbein's theory of reasoned action (Fishbein & Ajzen, 1975), assume that people integrate beliefs and values according to some simple decision rule, usually a multiplicative one. They then choose the option with the largest criterion value, e.g. the largest expected utility, and act accordingly.

These models seem plausible; perhaps they indeed are little more than common sense. They imply that once people are credibly informed about the importance of a given type of health protective action, they should behave rationally. But people often do not act rationally, at least not in this sense of the word. Decision model approaches are virtually useless for understanding health protective behavior.

Weinstein's stage model is an attempt to account for decision making as a process involving several stages. It is broader in its conception of the important factors in action, as compared to traditional decision models. It includes the following stages:

(1). "Has heard of hazard"
(2). "Believes in significant likelihood for others"
(3). "Acknowledges personal susceptibility"
(4). "Decides to take precaution"
(5). "Takes precaution"

Although it still largely untested, Weinstein's model seems rather promising and it is certainly an interesting alternative to the traditional health belief model. It is, however, mainly a cognitive model. Weinstein argues for a cognitive model by stating that "new preventive actions usually involve high-level cognitive functioning and advance planning" (p. 358). In the case of radon, it is doubtful if one can classify the needed actions in testing one's home as "high-level cognitive functioning", although Weinstein illustrates his model with the radon case. The fact that a number of steps are postulated does not mean that there is high-level cognitive functioning. In addition, even if high-level cognitive functioning is called for, one can still question a model that generally ignores emotional influences. Such influences seem to be especially likely to occur in steps 3 and 4. There is reason to believe that emotional influences are more important when more sophisticated cognitive functioning is involved.

In spite of this criticism, Weinstein's paper is recommended for several insights and suggestions, including the importance of prompts and reminders in eliciting action and the choice of time horizon.

Sjöberg used the concept of mental energy to explain relapse in addictive behavior. According to him, mental energy is needed for the orderly regulation of action. Under emotional agitation, competing action tendencies arise, often in the form of tempting imagery. These action tendencies require additional mental energy resources for processing, and since these resources for processing are finite, the cognitive system will work at a lower level, accepting low quality "excuses" and rationalizations. Hence, the crucial problem in pursuing longterm goals is that supply of mental energy.

Similarly, Weinstein suggested a "messy desk" analogy to health protective actions. Such actions must compete with many other duties and demanding activities. Clearly, the difficulties of the messy desk can be explained in terms of limiting cognitive capacity or in terms of limited energy resources. The latter approach has the advantage of phenomenological plausibility. In addition, most health protective behaviors are <u>not</u> cognitively demanding. Testing one's home for radon or quitting smoking is not cognitively difficult to do, the difficulty is <u>doing it</u>. This is why a cognitive model is likely to be insufficient in accounting for lack of rationality in health protective behavior.

<u>11. Message format and contents</u>

Message format has been found to be quite important in determining how people react to a message (Magat, Payne & Brucato, 1986).

A traditional issue in work on attitude change is that of one-sided vs two-sided messages. A one-sided message gives only arguments pro or con an issue, while a two-sided gives both types of arguments. It has been found that one-sided messages are more efficient when the issue is unfamiliar (Chu, 1967).

It is commonly believed that messages that are "personalized" are more effective when it comes to behavior change. But what is "personalized"? The concept is rather unclear and quite different aspects of communication are believed to lead to "personalization". Thus, personalization of risks has been suggested to occur when (a) communication is face-to-face rather than <u>via</u> mass media, (b) communication contents directed to parents refer to children at risk, and (c) whenever the respondent is made to believe that he or she is personally at risk. These three specifications of personalized risk are very different.

Rogers (1983) and Leventhal (1970) studied the vividness of the information and the personal relevance of the outcomes. While expected effects were found in terms of fear and perceived vulnerability, it was not clear that actual protective behaviors were more likely under fear arousal (Leventhal, 1986).

Petty and Cacioppo (1981, 1986) suggested a distinction between central and peripheral routes to persuasion. The central route involves thinking and elaboration and leads, according to the authors, to more permanent attitude change. The peripheral route is typically evoked in topics of small concern to a person. Much less and more superficial processing is involved in this case. In the peripheral route, efficient cues may be "irrational" or superficial.

Communication technology now makes it possible to make complex information accessible in a dialogue mode. A computer program for communicating radon risk has been developed by Florig and Morgan (no date). The program simulates a house and shows how various factors affect the radon level. It has not yet been evaluated but it seems like a promising development. There may be a risk, however, in excess credibility in such a computerized mode of communication. Real houses have many characteristics that cannot be simulated and generalization from the computer house to a real house is therefore unjustified however tempting it may be.

A final matter of importance is to what extent risk communication needs to be tailormade to fit each risk. Can general principles be designed or does each communication effort need its own research agenda?

12. Personality, risk taking, and attitude change

12.1. Personality and behavior: general

People vary greatly in how they respond to threats, risks and attempts at communication. The field of personality psychology might be expected to explain this variability, but results so far have been meager. This is a reflection of general difficulties in finding trait measures with sufficient generalizability. Mischel (1973) summarized the field and came up with the disconcerting conclusion that personality dimensions seldom explain more than 10 percent of the behavior variance. Many have since attempted to disprove this conclusion but so far with little success.

Notwithstanding, personality measures might give some additional understanding of risk attitudes, even if it is marginal. For example, Sjöberg and Drottz (1988) found in a study of nuclear power plant personnel that generalized anxiety scores correlated about 0.15 with job risk perception. (This correlation is statistically significant).

12.2. Vigilant vs. defensive response to threats

Recent work on attitude change has found personality correlates for reactions to communicated messages (Eagly, 1981). Janis (1962, 1982) studied the contrast between those who react with vigilance and those who ignore risks .

These notions were applied by Stallen and Thomas (1988) to how people respond to industrial hazards. They suggested a typology of reactions to risk: secure, accepting, vigilant and defensive. The first two consist of people who really do not see a problem. The vigilant and the defensive acknowledge the existence of a problem, but they differ in hope. The defensive lack hope and see no way they can personally control the risk, while the vigilant have hope. The study was of a preliminary character but the concepts may be fruitful in further work.

12.3. Need for cognition and uncertainty orientation

Cacioppo and Petty (1982) suggested a dimension that they called need for cognition, based on previous work by Cohen (Cohen, Stotland & Wolfe, 1957). Need for cognition is a need to structure and understand the world. People who are high in need for cognition enjoy complex rather than simple tasks, and may be more responsive to focused arguments than to peripheral cues.

Cacioppo and Petty devised a scale for measuring need for cognition and successfully predicted that those high on the scale would prefer a complex to a simple task, while the opposite would hold for those low on the scale.

Another somewhat related dimension of potential interest is uncertainty orientation (Sorrentino, Short & Raynor, 1984). According to Sorrentino, Short and Raynor, uncertainty orientation determines whether a problem situation (a situation characterized by uncertainty about the self or the environment) triggers approach or avoidance motivation. People who are uncertainty oriented would be more attracted to such a situation, especially if it is ego related (relevant to self esteem), and would be more influenced by cognitively demanding arguments. Certainty oriented people would be more influenced by cognitively simple messages and they would rely on heuristics rather than elaborate cognitive processing. On the other hand, if the situation does not pose an important ego related problem, these trends would be reversed, i.e., certainty oriented people would use more elaborate processing than uncertainty oriented people.

Sorrentino and coworkers proposed to measure uncertainty orientation by combining a sentence completion test scored for uncertainty imagery with a questionnaire measuring authoritarianism.

The concept of uncertainty orientation is related to the cognitive psychological notion of levels of processing (Schneider & Shiffrin, 1977). Cognitive processing can be carried out either in an elaborated, conscious manner or in a more automatic, simplistic and undemanding way. Petty and Cacioppo (1986) suggested that high-level processing is more likely with personally highly relevant and involving thought contents. This notion enjoys a high level of credibility in current attitude research, but recent work casts some doubt on its generality.

Sorrentino et al. (1988) found convincing evidence for this prediction in an experimental study. Personal relevance increased systematic processing of message contents only for uncertainty oriented subjects, the opposite was true for certainty oriented subjects. For the latter type of subjects personal relevance decreased systematic processing. This is an interesting finding because it suggests that the currently popular notions of Petty and Cacioppo (1986)[1] only if people are uncertainty oriented. In a practical application to risk communication, we might expect most people to be certainty oriented and hence most responsive to little elaborated messages, provided that the risk is conceived as a personal threat.

It would be interesting to test the hypothesis that a risk message is most effective if it is cognitively undemanding and if the threat is personalized. The hypothesis also implies that the message is most effective if the risk is abstract and the message cognitively elaborated. The hypothesis follows from Sorrentino et al., provided that most people are certainty oriented. For uncertainty oriented persons the trends would be opposite. A three-way interaction between certainty orientation, elaboration of risk message and personalized vs. abstract risk is thus predicted.

It may be the case that different cultures differ in uncertainty orientation. Sorrentino et al. suggested that their data indicated a lower level of uncertainty orientation in Canadian than in US students. This would explain why Petty and Cacioppo, working with US student groups, obtained results showing that people process information in a more sophisticated manner if they are personally involved. Sorrentino et al. also suggested that certainty orientation may be the dominant trend in the population and that the hope that people are more rational when they face a personally important problem therefore is futile (Sorrentino & Hancock, 1987).

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[1]. That is, that personal relevance of an issue increases the level of processing and makes people more likely to be influenced by more elaborate argumentation.

12.4. Health concern

Smith et al (1987) used a potentially important variable that might be termed "health concern": a 4-category rating of the statement "You always ask your physician a lot of questions or regularly read articles about your health". The idea of measuring health related attitudes in order to account for some of the individual variation in response to risk is promising. It measures individual behavior at a level close to risk perception in meaning. Research on behavior and attitudes has repeatedly found that the most behavior relevant attitudes are those that are semantically close to the behavior under study.

Miller (1980) suggested a variable for measuring monitoring with regard to illness symptoms. People high in monitoring would be more prone to see a doctor whenever they would be worried about their health. Miller, Brody and Summerton (1988) reported some evidence for this hypothesis, and also found that those high in monitoring were low in desire to control. They left that to the doctors. The people who tested very early for radon, in the New Jersey study confirmatory sample, appear to resemble the "monitoring syndrome" described by Miller et al. They were quite concerned and kept extensive files about radon, in stark contrast with the rest of the population. The Miller scale has not as far as I know been applied to the perception of hazards and technology risks of but it would be interesting to do so, in order to understand a part of the variance in risk response that might be attributable to personality.

12.5. Emotions and risk perception

Emotional states may also influence risk judgments and risk taking. Johnson & Tversky (1983) found that an experimentally induced mood had a global effect on risk judgments: a depressed mood appeared to create higher risk judgments. In contrast, Sjöberg and Winroth (1986) found that depressed subjects tended to rate risks as more acceptable than other subjects did. These findings may be reconciled if a depressed mood is associated with a more tolerant attitude toward <u>other</u> people's risk taking at the same time as it is associated with aversion for personal risk. Isen et al. (1982) found that positive emotional states were associated with risk taking in low risk situations but with risk aversion in high risk situations.

The perception of an acute threat and consequent high risk judgment can be expected to lead to anxiety, at least in those people who do not cope with the situation by means of denial. Anxiety, in turn, is known to lead to a deteriorated level of cognitive functioning (e. g. Deffenbacher, 1978), possibly because of a loss of short-term memory capacity (Darke, 1988). The likely result is procrastination since people under such circumstances easily fall prey to rationalized excuses for inaction.

13. Methodological issues

13.1. The definition of risk

Most research reviewed here has utilized risk ratings as dependent variables without a clear specification of the meaning of the term. However, risk is an unusually ambiguous word. It can denote the probability of harm, the size of a loss or a combination of the two (e.g. their product). Sjöberg and Drottz (1988) asked their subjects whether they judged risk as a probability, the size of a consequence or a combination of the two. While most subjects chose the first definition, many opted for the other two. There were systematic differences in risk judgments depending on the choice of risk definition. It may be important to pay attention to how the subjects understand the term risk in interpreting their judgments.

13.2. Response rates

Table VI indicates that response rates have been fairly low in these studies. The table also gives the total number of respondents which could be used for data analysis and as can be seen that number varies by an order of magnitude across samples.

The last column gives the final response rate of all those that were eligible for inclusion in the sample. It is the outcome of several factors which give rise to drop-out. For example, in the Florida risk attitude study (Section 5.9, page 37) 30 percent of eligible homeowners could not be reached on the telephone and of those that could be reached, 40 percent agreed to participate. Hence, the total response rate is given as 28 percent.

Sometimes the researchers have given conditional rather than absolute final response rates. In the NYSERDA study, comparison sample, followup survey, the response rate is given as 72.2 percent. However, this is in percent of those who completed the baseline survey, not of all those who were eligible for inclusion. The latter percentage is more informative as to the information value of the data obtained, and it is considerably smaller (36 percent). (Strangely enough, the results for the monitored group are given according to the principle suggested here).

I have tried to distinguish, whenever relevant, between acceptance to participate and actual response. In some cases the reports do not give any information about how many people were approached to give a certain number of people who agreed to participate. This is a piece of information that should have been included. Even if data do not aspire to strict statistical representativeness it is useful to know if 10 or 90 percent of those approached accepted to participate.

The overall picture is not too bad. Several studies reached respectable response rates. Some comments about the lower values are in order, however.

...e 10. Response rates in cited radon studies, measured as the percent of the studied sample that (a) accepted to participate, and (b) gave usable responses.

Type of data	Number of collection method	Prop. usable respondents	Prop. accept.	Prop. resp.
Maine study, Section 5.2.	Telephone	221	No info.	91
NYSERDA study Section 5.4				
Monitored group				
Baseline	Telephone	2231	No info.	97
1st followup	Telephone	2087		91
2nd followup	Mail	ca.1700		74
Comparison group				
Baseline	Telephone	252	50	50
1st followup	Telephone	182		36
New Jersey study Section 5.5				
Random sample	Mail	657	78	79
Confirmatory sample	Mail	141	47	92
New Jersey study of radon information Section 5.6	Mail	271	No info.	75
New Jersey study of communication format Section 5.7[2]	Mail	1948	34	67
Maryland study Section 5.8				
Baseline	Telephone	1547	56	56
Followup	Telephone	1528	60	60
Florida study Section 5.9	Telephone	837	28	28
Florida personality study, Section 5.10	Mail	320	84	38
Onondaga study Section 5.11	Mail	204	No info	81
Washington, D.C., study of mitigation Section 6.4	Mail	709	77	77

Notes. 1. A few of the minor, exploratory studies are excluded.
2. All data have not been collected at the time of writing.

Desvousges et al. were concerned about their response rate (which is by no means dramatically low) and suggested that it may have been related to the fact that they had to carry out their data collection during the Christmas holidays. However, since their response rate is no worse than that obtained by others, it seems that the explanation may be less credible. Perhaps there is a general decline in response rates to telephone interviews because of their increasing use and new computer technologies.

What are the possible effects of these low response rates? Weinstein et al. argued that the people who respond probably are more concerned and know more and that, therefore, risk denial may be underestimated by these data. On the other hand, the better studies have examined some characteristics of respondents as compared with the population being studied. They have often failed to detect important differences, with the possible exception of gender. Women tend to be over represented among the respondents. Since women are known to be more risk averse than men, this is likely to create some bias.

13.3. Response scales

Weinstein et al. included "don't know" among their response alternatives and many people chose that alternative, perhaps partly because the radon issue was new and people in fact knew little about it. These responses were then treated as missing data, creating some problems with correlation statistics and regression models.

Krosnick and Schuman (1988) showed that more intense or extreme attitudes are just as vulnerable to such response effects as effect of the order of questions, with one exception: if a middle, neutral, response is provided it is usually very attractive to those who have only weak convictions.

Smith et al. (1987) obtained explicit ratings of information materials and found that homeowners discriminated little between them. This was so in spite of other findings in their study which clearly showed that one condition (the fact sheet) was inferior because it led to less knowledge and clearly exaggerated risk ratings.

It is an open question if responses to a question about willingness to pay for additional information give a valid indication of true demand.

Some work has indicted consistency between actual purchase and CV questions, however. Dickie, Fisher and Gerking (1987) found that there was no difference between the amount of strawberries actually bought and the amount that people just said that they would buy. This result has some interest but, as the authors point out, it cannot readily be generalized to WTP measures used for evaluating environmental protection measures. The latter usually concern much

more important issues and people can be suspected of letting the judgments be influenced by strategic considerations.

Methodology may account for the difference between the NYSERDA and New Jersey studies. In the NYSERDA study it was found that people exaggerated the radon risks while some aspects of data in the New Jersey study suggested the opposite. The NYSERDA results utilized the absolute level of the risk scale, transformed to a probability scale. However, the absolute level may not be very informative since scale levels are notoriously sensitive to contextual factors. Another big difference may be that the NYSERDA subjects all had agreed to have their homes tested. So they may have been more health-conscious, or risk averse, than the original NJ samples. In addition, it is unclear that risk may be straightforwardly translated to probability. The sheer lack of concern over radon, as shown by the lack of radon testing, indicates that people at least in that sense underestimate the risk.

Risk estimates can be given either in an absolute or a comparative manner. Absolute ratings utilize a scale from, say, 0 (no risk at all) to 7 (a very high, or severe, risk). Comparative ratings are done with reference to a standard, such as the average radon risk in the respondent's community or compared to smoking risk.

These two types of ratings can be expected to have somewhat different properties. Sjöberg and Drottz (1988) obtained comparative and absolute ratings of job risks from nuclear power plant employees. They found that comparative risk ratings carried information about both the reference level and the compared risk. The finding of Weinstein, Sandman and Roberts (undated) that absolute risk ratings showed the expected negative relationship to risk information, while comparative risk ratings did not, may have been due to these different informational bases behind the two types of ratings.

13.4. Time perspective

Almost all studies were concerned with short-term changes in knowledge, attitudes, and behavior. The persistence of attitude change is, of course, no trivial matter (Cook & Flay, 1978). For voluntary changes in behavior (e. g. testing and mitigation) it is probably necessary to have lasting changes in attitude. In the radon case, attitude changes need to last long enough to elicit testing and mitigation.

13.5. Attitude measurement

In some studies the coverage of attitude about radon risk has been sketchy. It would be useful to obtain more detailed information on the components of the risk attitude. This could be done with the help of a well established attitude model such as the one devised by Fishbein (Fishbein & Ajzen, 1975).

Concern has been found to be an important variable in some radon risk studies. There have been doubts that people can give valid estimates of concern or importance of attitude components (Slovic & Lichtenstein, 1971). In the field of political attitudes, for example, it has been hard to demonstrate that aspects of a candidates' policy judged as more important also in fact are more decisive when it comes to voters' choices. Krosnick (1988), showed that these difficulties were largely methodological, that people can make valid judgments of importance, and that more important dimensions also have a larger weight in accounting for choice.

Attitude measurement tends to utilize rather simple responses and does not usually involve attempts to get more detailed information about the thought process behind risk attitudes and perceptions. Bostrom (1989) attempted just that, however. She collected extensive interview data about radon attitudes and perceptions from 24 subjects, who were all reasonably knowledgeable and involved. She devised an interesting scheme for scoring the accuracy of people's notions about radon and came up with several (preliminary) conclusions. People were found not to understand concepts of radioactive decay, to have scanty knowledge about mitigation, to be unclear about the effects of radon (many mentioned cancer unspecifically, not lung cancer), and to know little about the concept of a soil gas. Some of these findings could perhaps have been obtained with a more conventional and simple approach, but the results still indicate that further work along this line could be of value.

13.6. More detailed information about crucial decisions

The studies reviewed here have collected an impressive amount of information about how people perceive radon risks. Still, there are some types of information that are missing.

Several projects collected data on reasons for not testing for radon, such as those shown in Table II above from the New Jersey study. However, I lack comparable data from testers on why they have tested. Such data may be even more informative than reasons for not testing, which seem a bit like excuses rather than real reasons. There may be several routes to testing that differ in interesting and important ways, e.g. health concerns, social pressure and property value concerns.

14. Discussion and conclusions

14.1. Summary and discussion

Radon is a risk with certain unique properties. It shares some of the characteristics of all risks from ionizing radiation (slow effects in the form of cancer, a risk from a physical agent that cannot be sensed). At the same time it is a risk that threatens people in their homes and homes are usually perceived as safe places under one's own control and responsibility.

Radon risk has been compared to such life-style risks as smoking or drinking alcohol. The similarity is that people take

these risks as private individuals. Society is reluctant legislate the risk level to which they can expose themselves. The must act voluntarily to mitigate or eliminate these risks.

There are also differences between radon and life-style risks. First, radon exposure does not confer any benefit as smoking and alcohol do. Second, it is not clear who, if anyone, is responsible for radon risk. Radon risks were largely unknown to the US public before 1985 and most home owners bought their current houses before then.

Reducing a life-style risk involves making a commitment to action in spite of temptations to delay action. In this sense, there is a further similarity between radon and life-style risks. Many people in one of the studies reviewed here became "procrastinators", i.e. they changed from indifference towards the risk to acknowledging the necessity of action "in principle". It is well known that people find it very difficult to quit a risky habit and that rationalized delays are very common. It is too early to tell if the same phenomenon will occur for radon risk but it is possible. On the other hand, testing for radon and mitigating require only two discrete actions while the ex-smoker has to resist cigarettes several times a day. People do not have to quit a habit (or develop a new one) in order to test and mitigate for radon.

Most smokers know that their habit is unhealthy but they procrastinate in spite of their own knowledge of what is in their best long-term interest. Something similar seems to be going on in the case of radon. More information will therefore probably not be sufficient. It has even been argued that more information will provide people with material for twisted rationalizations for why they have not tested and can go on postponing it indefinitely (Weinstein, Klotz & Sandman, 1988). It is furthermore well known from research on such hazard warnings as for floods and hurricanes that people tend to ignore them if the warnings are not directed to them personally in a very concrete manner (Mileti & Sorensen, 1987) or supported by feedback from friends (Kunreuther et al., 1978).

In the present report I have reviewed several studies of how people perceive and respond to radon risk. Initially it was believed that information about radon risk might give rise to panic reactions, but experience has not confirmed this concern. On the contrary, people are often quite indifferent to the issue, at least in regard to their own homes. This indifference can be interpreted as a manifestation of a rather general tendency to deny health risks and it has been suggested that denial of radon risk is moderately strong compared to other kinds of denial.

Many people are outright negative to radon testing. Pennsylvania authorities at one point went from door to door and offered free radon testing. Still, about 50 percent refused to have their homes monitored. Some people are concerned that rumors of a radon problem will affect property values in an area.

It is worth stressing that people tend to be indifferent to radon risk in spite of the fact that the EPA action level is quite high compared to other risks. The actual risk level seems to be a poor predictor of public response to risk. The action level in Sweden is 2.5 times higher than the US level and it corresponds to the lung cancer risk of smoking a pack of cigarettes per day. Still, Swedes are just as indifferent to radon risk as Americans.

As might be expected on the basis of these facts, there is usually only a weak correlation between the scientifically estimated risk level, as physically measured, and the level of perceived risk. Some people with low levels of radon in their homes are quite concerned while others, with quite high levels, are indifferent. This low correlation may partly arise from the fact that the physical measurements are not perfect indicators of the actual risk level. The risk also depends on how much time people spend in the house, their age and other factors. Still it is reasonable to conclude that there is a weak correlation between perceived and actual radon risk.

There is little evidence suggesting that people do not believe that the radon readings are accurate or that the risk assessments are incorrect. They probably believe that the risk is there, in principle and for people in general, but that they themselves are for various reasons less vulnerable or more lucky. It is also possible that or they just do not care about getting involved in protecting themselves against another risk, they simply go ahead and take it.

The effects of information about radon risk provide a partly different picture. Two studies have shown that people revise their risk estimates in the "right" direction, i.e. in the direction suggested by the readings of radon levels in their homes. Still, other data suggest that even for risk revisions there may be irrational denial factors at work. There is some support for the thesis that people are more inclined to accept that <u>other</u> people's homes in their community may be at risk than that <u>their own</u> homes may be at risk.

If actual risk is not strongly correlated with perceived risk, then what accounts for perceived risk? There are some correlations with background data. Older people are less worried about radon, and parents of small children more so. In some studies women have been shown to be more worried than men, but the gender difference is much smaller for the perception of radon risk than for many other types of risk. People with a family member with cancer were more concerned about radon in one study. Some personality variables have been suggested as predictors of perceived radon risk but so far little research has been carried out on this issue.

Nevertheless, these factors are only weakly related to perceived radon risk. There is simply not enough research available to support more definite statements about what factors influence perceived radon risk.

People seem inclined to deny radon risk as they do a num[redacted] of other health related risks. This reaction is in contrast to the attention given to the risks from industrial pollution. Thus, there is no tendency for people to deny risks in general. Only certain risks are denied. It would be of interest, in future work, to investigate why some risks are denied and others exaggerated. It may be that risks that are denied are risks where the threatening agent is associated with the self.

I suggest that radon risk perception is a special case of ego-related risk, i.e. it is a risk that is closely related to self conceptions. This hypothesis is derived from evidence that people tend to perceive their homes as parts of their selves, especially if they have lived in them for a long time. And there is a tendency to deny that something as closely related to oneself as one's home could be threatening. Reactions to radon risks may therefore be related to perception of one's home. It is conceivable that risk communication would be more efficient if the risk would be clearly separated from the home.

The hypothesis is supported by data that indicate that people with a longer history of living in a house are more likely to deny radon risk. Other supporting data show that people react strongly to radon risk when it is introduced in their neighborhood - not on their homes. Part of this reaction is probably a result of moral indignation over being exposed to a risk by someone. Peopl[redacted] strongly resent a loss of control, and they tend to perceive tha[redacted] which they can control and are responsible for as benign.

As an alternative explanation of perceived radon risk, risk reactions could be seen as dependent on a number of risk characteristics such as those suggested by Fischhoff et al. (1979). The problem with that approach is that it assumes that risks reactions are based on cognitive information integration. It misses the motivational and emotional aspects of risk perception. Few attitudes are more likely to be dependent upon emotional reaction than risk attitudes. In addition, it is well known that attitudes in general cannot be well explained by beliefs (McGuire, 1985). This is not to say that there is not some correlation between risk attitudes and risk characteristics. The question is what the correlation means. Slovic et al. assumed that attitudes are caused by beliefs. It is more likely that both attitudes and beliefs are caused by an underlying common image (Sjöberg & Biel, 1983).

Concern about radon risk may be problematic by itself. It has been reported in some work that higher concern about radon leads to more blame attributed to the government and puts less responsibility on the individual. Higher awareness, on the other hand, was correlated with greater perceived responsibility on the part of the homeowner. The question is whether it is possible to increase awareness without, at the same time, generating increased concern. More research on this topic could be fruitful.

Communication about radon risk with the general public has been studied in two major investigations, one of which was especially concerned with mitigation. These studies also

investigated the effects of a major attempt by a television channel in the Washington, D.C., area to encourage people to buy test kits, available at reduced price in grocery stores. The television campaign created an impressive interest in buying test kits. Over 100 000 kits were quickly sold and demand was by no means exhausted. About 6 percent of the home owners in the area bought test kits. However, only about half of those who bought the kits turned them in for analysis and few people who had elevated radon levels in their homes reported any effective mitigation beyond such behavioral measures as keeping windows open more often.

The EPA-sponsored outreach activities in a Maryland community were probably more effective than the simultaneous television campaign in stimulating people to test for radon. The proportion that tested their homes rose from about 5 to 15 percent. There is some evidence that the television campaign was effective in making people aware of radon risk, but less effective in stimulating them to act. A similar finding was reported in a New Jersey study of smaller scope where it was found that there is a link between risk perception and action but that the link was quite weak. The weak effects of the television campaign are in line with extensive experience from other studies of health-related public service messages. The effects are usually quite marginal.

A few studies have investigated knowledge about radon and found that people are fairly well aware of its general properties, although they lack specific knowledge. They may also lack knowledge about how to test for radon and whom to ask about testing and mitigation. They are especially uncertain about mitigation and its costs.

It is relatively easy to inform people about radon facts. However, there is little relation between knowledge and tendency to test and mitigate. This finding is in line with a generally noted lack of relationship between attitudes or beliefs and knowledge.

Risk communication is a topic of much current concern. EPA has published a brochure containing "Seven cardinal rules of risk communication" (U. S. Environmental Protection Agency, 1988 b). It is reasonable to ask what relevance such advice has in a concrete case such as radon risk.

The Cardinal Rules make a rather pallid impression, on closer scrutiny. To be more specific, the communicator is advised to

- Accept and involve the public as a legitimate partner
- Plan carefully and evaluate your efforts
- Listen to the public's specific concerns
- Be honest, frank and open
- Coordinate and collaborate with other credible sources
- Meet the needs of the media
- Speak clearly and with compassion

It is hard to avoid the impression that these rules have been designed for a case where the communicator wants to reassure the

public that the risks are smaller than they fear. Such risk exist, but the problem with radon risk is the opposite. Still, the brochure never states that its applications are only one type of risk, it seems on the contrary to be aimed at very general application.

Since radon has been stated as one of the major threats to public health it would be valuable to have rules designed for the case when people need to be alerted to a danger. The fact that this has not been done already may be due to the fact that radon in homes constitutes no threat to the industry, while public concern over means of energy production and disposal of industrial waste does constitute such a threat, at times.

There is an increasing interest in research on mitigation of radon risk. It has been found that there is a rather weak correlation between scientifically estimated risk and mitigation, but a stronger correlation between perceived risk and mitigation. This is an example of a quite general truth: people react to what they perceive reality to be rather than what it really is.

It is not yet clear how much mitigation one can expect in different circumstances. Some data certainly suggest that home-buyers are likely to be among the most responsive to the radon risk message. On the other hand, not all data on mitigation are as negative as the ones reported in the study of the Washington, D. C., television campaign. A follow-up of highly motivated New Jersey homeowners found a high rate of mitigation. Some Swedish data were in between the two American data sets. (Cultural comparisons are risky, however, since many crucial aspects, such as the economics of housing and mitigation, differ dramatically between Sweden and the USA).

A few studies have investigated the format and contents of radon risk messages. A major study compared "command" and "cajole" styles of communication. That study also investigated and compared qualitative vs quantitative types of information. The results were somewhat complex and differences were not large but there was a tendency for a command style of communication to be most effective. That study also compared the use of a brief fact sheet as a replacement for more extensive brochures. It was found that those who had been given the fact sheet tended to be more concerned about their risk level than others. This was true in spite of the fact that the fact sheet was only given to those who had very low levels of radon in their homes.

The investigators concluded against the use of the fact sheet. That may be a reasonable conclusion for that particular group of homes and their owners. It may still be the case that a short fact sheet would be useful for people who have higher levels of radon measured in their homes. It has been found that people, if given a basis in rich information material, tend to construct defensive denial conceptions. In other words, more information makes it easier for them to come up with rationalizations for lack of action. Of course, a short fact sheet need not be very similar to the one used in the NYSERDA study.

There have been few attempts to analyze the contents of radon risk attitudes. So far, most data suggest that health concerns are most important. Many studies could have profited from a more extensive mapping of the components of risk attitudes, using one of the well known models of attitude measurement, such as that devised by Fishbein (Fishbein & Ajzen, 1975).

Many of the studies reviewed here used a risk concept that was not further explained to respondents, who were asked to judge such variables as size of perceived radon risk. However, other research has shown that people interpret the word risk in various ways. There may be differences among genders and educational strata in whether respondents interpret risk as probability, as the size of the consequences or as a combination of these two concepts. Interpretations of results may be misleading if this factor is neglected.

Another interesting methodological aspect is the response scale. It is difficult to translate the judgment of seriousness of a risk into subjective probability, and seriousness could refer to either probabilities or consequences. On the other hand, it is notoriously difficult to obtain valid judgments of small perceived risk. As an alternative, comparative risks often are used to assist people in judging small risks. Radon risk has been compared to the risks of smoking, for example. This approach is well worth trying but one should bear in mind that comparative risk judgments are more complex than absolute ones because they involve two risk levels rather than one. Risks are probably perceived in a context of several threatening events and conditions and the judgment of any given risk may well be affected by how certain other salient risks are perceived. For example, people with a very risky job may perceive their radon home risk as minor just because it is implicitly or explicitly compared to job risk.

In many circumstances people are most strongly affected by social diffusion of information and attitudes, i.e. what their friends and neighbors and locally prominent people tell them. For this process to spread quickly there must be many willing "informers". However, in the case of radon there are still very few people who have shown any active interest in the issue of home testing, and those who have informed their friends and neighbors have sometimes met with hostile reactions. It would be of interest to investigate such obstacles to social diffusion.

There has been little work on property values and house sales as related to radon. There are indications that this aspect is very important for some homeowners. An interim report on radon risk communication states that "Some Regions indicated that many of their radon-related telephone calls focus primarily on the real estate implications of radon rather than on health concerns" (U.S. Environmental Protection Agency, 1987 a, p. 4).

A Swedish study recently found that radon did not seem to affect house prices. Informal information from realtors in the USA confirms this finding. However, a Colorado study showed that many

people are quite concerned about getting a house tested for r[redacted] before they buy. Some 50 percent of the home-buyers participat[redacted] in the study reported that they had done so. These people also tended to mitigate much more often than those who bought test kits and monitored their own homes. Indeed, the prevalence of mitigation at or above the action level of 4 pCi/l was 100-200 times as great for home-buyers as for homeowners. People whose employer was especially concerned about radon risk and those who were in contact with a knowledgeable realtor or building contractor were especially prone to test and mitigate. These results were obtained in a state where radon risks had not been extensively discussed in the media.

The fact that real estate prices are not affected by radon may be related to the prevalent information that a radon problem usually can be fixed quickly and fairly cheaply. There has been little awareness so far about how often continued monitoring for radon will be required and additional mitigation will have to be undertaken. When this issue is given wider publicity there could be an effect on real estate prices.

Virtually all research so far has been conducted with homeowners so the social strata that have been represented have not been representative of the whole population. We do not know how people who rent their homes respond to radon risk, or how involved their landlords are in monitoring and mitigating su[redacted] houses. There is also very little work reported about attitudes [redacted] radon in schools, public buildings and workplaces.

14.2. Conclusions

Research on radon risk perception and risk mitigation has not proceeded very far, simply because the problem is so recent. However, it is possible to draw some conclusions on the basis of existing research results.

(1). The major problem is indifference to high-level risk, especially among people who already live in a home that may have an elevated radon level.

(2). Home buyers are probably much easier to alert to the issue, with ensuing radon testing and mitigation.

(3). Studies of variations in risk communication material suggest that brief, to the point, recommendations about what to do are better than longer messages that allow the reader to form his personal opinion. It is just too likely that these personal opinions will be defensive risk denials.

(4). Even the most effective mass media campaigns and outreach community programs investigated so far have succeeded in stimulating only a small fraction of the population of homeowners to monitor and mitigate. Whether these campaigns have justified their costs has not been determined. A community outreach program

An experimental study of risk communication formats (Weinstein, Sandman & Roberts, 1989) found that a brief statement about the action level was best for eliciting continued concern. On the other hand, full information about the risk, including numerical, risk comparison data and graphical information, was best for creating a balanced view. A major difficulty in this study was that of communicating absolute risk levels. A graphical display seemed sufficient to make people disregard a difference in absolute risk level in the range 1-25 (between radon and asbestos).

The NYSERDA fact sheet was somewhat similar to the condition of stating the action level only in the study by Weinstein, Sandman and Roberts (1989). In particular, the fact sheet did not specify anything about the risk of radon levels lower than 4 pCi/l. One can conclude that a brief message is most likely to elicit continued concern among home owners.

Another reason for favoring very brief messages is that people have difficulty in handling information and that they are not very motivated to obtain it. Studies of public service information in the form of printed brochures usually have shown that most people do not bother to read them and that those who do read them quickly forget most of their contents. Other investigators have studied the effects of level of risk communicated and found that a more threatening message tended to invite more risk denial.

The conclusion is that the most effective message format and contents should be brief and not too threatening. Messages should furthermore emphasize that radon is a risk that must be taken seriously. Comparing it to some other risks, such as smoking, can help people understand its size. It should be clear that it is simple and cheap to test for radon and relatively simple and cheap, in most cases, to mitigate. Quantitative information about the risk level is to be preferred to qualitative, and a "command" tone is better than a "cajole" tone for eliciting radon testing.

Another possibility involves switching to the common international measure Bq/m^3 rather than pCi/l. Since 1 pCi/l = 40 Bq/m^3 such a switch would involve larger numbers that could by itself have an effect (whether positive or not).

These conclusions should be regarded as preliminary. They are based on a rather complex set of findings from radon risk communication studies and from communications research in general, as well as basic principles of cognitive psychology.

It is important to determine what the goals of radon risk communication should be. Should it be aimed at inducing behavior change, i.e. testing for radon and mitigation if the levels are high? Or should it aim at informing the public so that they can make well-informed decisions? If the latter path is chosen, some problems arise. First, it is very hard to know if a person has made a well-informed choice. Indeed, the concept itself needs considerable clarification. Second, information is by itself

insufficient to induce much behavior. The studies have found very low correlations between acquired knowledge and testing for radon.

Research methodology is an important issue in a discussion of risk communication. The empirical studies reviewed in the report vary considerably in this respect. Virtually all were quantitative and employed either mail or telephone survey methods but they differed in many other respects.

There is evidence that people are not very eager to participate in surveys of this kind. Response rates around 60 percent or lower are common in spite of several reminders. Some of the problems of low response rates have been attributed to data collection during holidays, but there is no evidence that these particular studies yielded especially low response rates. Indeed, the US public probably is saturated with opinion polls and survey investigations and it is becoming more and more difficult to recruit respondents for new waves of data collection.

It should also be pointed out that several of the major studies reviewed here reported quite good response rates and that there is no evidence of any major bias in the samples of respondents.

It can still be noted that women seem to be more likely to accept invitations to participate in radon risk studies than men and the result is that they are overrepresented in some of the studies. Also, the samples tend to consist of highly educated and financially secure people, possibly because the studies have focused on home owners rather than renters.

Attitude change has been studied for decades. It is usually quite hard to change people's attitudes, especially to change them permanently and to affect behavior. Changes tend to be short lived. The empirical work on radon so far has not followed attitudes for a more than a few months, with the exception of the NYSERDA study. Longer follow-up times are called for in order to get a realistic idea about how persistent attitude changes are.

It would probably be fruitful to investigate in more detail how people reason with regard to radon and testing. One piece of information that is lacking in these studies is <u>why</u> people test (there is data on why people do <u>not</u> test). Testing can be motivated in many ways, for example health, economic factors or conformity to expectations by friends. The reasons people have for testing could stimulate the formation of hypotheses about effective methods of risk communication.

Qualitative information about the conceptions and misconceptions that people have about radon would also be of interest. Among other things, such conceptions could be of crucial importance for mitigation. Some people may believe that radon is most likely to be found in the attic rather than the basement of a house (since many gases are lighter than air). Ionizing radiation is also something that people know little about and they tend to espouse several misconceptions.

appeared to be more promising than a major television campaign, although they probably reinforced one another.

(5). Further research should be conducted on the components of radon risk attitudes and conceptions, in particular why some people test and mitigate. Interpretation of findings would probably be helped by more information on how people interpret such key terms as "risk".

(6). There are important ethical aspects of radon risk that have been neglected in research. Some people see nobody as responsible for a radon problem, others may blame themselves, contractors or the government. The owner of a house may or may not feel responsible for the health of others who live in it. At the time of a house sale there is a special ethical problem if the seller knows there is a radon problem. These are important matters for further research.

(7). There is a total lack of data on how renters, as opposed to homeowners, perceive risk and how their landlords view the radon issue. There is very little data on the perception of radon risk in public buildings and workplaces. Perhaps some homeowners can be alerted about their home risks if they get involved in school building risks.

(8). Although the sparse data that exist on the issue suggest that radon risk does not reduce property values, the issue certainly needs much more investigation. Will the lack of effect persist when more experience with mitigation and its costs and effects accumulate? People may at this time be overly optimistic about how easy it is to "fix" a radon problem permanently. Do people see monitoring as a potential economic threat? Or will lack of monitoring and disclosure of results at the time of a house sale be the real economic threat in the sense that homes that have not been tested will sell for a lower price?

15. References

Adler, R., & Pittle, D. (1984). Cajolery or command: Are education campaigns an adequate substitute for regulation? Yale Journal of Regulation, 1, 159-194.

Åkerman, J. (1988). Economic valuation of risk reduction: The case of indoor radon. EFI Research Report 91-7258-266-9. Stockholm, Sweden: Stockholm School of Economics.

Åkerman, J., Bergman, L., & Johnson, F. R. (No date). Paying for safety: Voluntary reduction of residential radon. Unpublished manuscript. Stockholm, Sweden: Stockholm School of Economics.

Anderson, C. A., & Sechler, E. S. (1986). Effects of explanation and counterexplanation on the development and use of statistical theories. Journal of Personality and Social Psychology, 50, 24-34.

Anderson, C. H. (1983). Abstract and concrete data in the perseverance of social theories: When weak data lead to unshakable beliefs. Journal of Experimental Social Psychology, 19, 93-108.

Anderson, J. R. (1985). Cognitive psychology and its implications 2nd Ed. New York: Freeman.

Baum, A., Fleming, R., & Davidson , L. M. (1983). Natural disaster and technological catastrophe. Environment and Behavior, 15, 333-354.

Becker, M. H. (Ed). (1974). The health belief model and personal health behavior. Health Education Monographs, 2(4).

Bergman, L., Söderqvist, T., & Åkerman, J. (1988). Subjective valuation of radon reduction. EFI Research paper 6358. Stockholm, Sweden: Stockholm School of Economics.

Bostrom, A. (1989). Risk perceptions: An approach to perceptions of risk processes, a mental models analogy and an application to radon. Unpublished manuscript. Pittsburgh, PA: Center for Risk Perception and Communication, Carnegie-Mellon University.

Cacioppo, J. T., & Petty, R. E. (1982). The need for cognition. Journal of Personality and Social Psychology, 42, 116-131.

Chaiken, S. (1980). Heuristic versus systematic information processing and the use of source versus message cues in persuasion. Journal of Personality and Social Psychology, 39, 752-766.

Chess, C., & Hance, B. J. (1988). Alerting the apathetic and reassuring the alarmed: Communicating about radon risk in three communities. Final Report submitted to the Office of Policy, Planning, and Evaluation, EPA-230-08-88-036.

Washington, D. C.: United States Environmental Protection Agency.

Chu, G. C. (1967). Prior familiarity, perceived bias, and one-sided versus two-sided communications. Journal of Experimental Social Psychology, 3, 243-254.

Cleveland, W. S., & McGill, R. (1984). Graphical perception: theory, experimentation, and application to the development of graphical methods. Journal of the Americal Statistical Association, 79, 531-554.

Cohen, A. R., Stotland, E., & Wolfe, D. M. (1957). An experimental investigation of need for cognition. Journal of Abnormal and Social Psychology, 51, 291-294.

Cohen, B. L., & Gromicko, N. (No date). Surveys of radon levels in U. S. houses. Unpublished manuscript. Pittsburgh, PA: University of Pittsburgh.

Cook, T. D., & Flay, B. R. (1978). The temporal persistence of experimentally induced attitude change: An evaluative review. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 11, pp. 2-57). New York: Academic Press.

Cvetkovich, G., & Earle, T. C. (1988). Platitudes and comparisons: A critique of current (wrong) directions in risk communication. Paper read at the Annual Meeting of the Society for Risk Analysis, October 30 - November 2, 1988, Washington, D. C.

Darke, S. (1988). Effects of anxiety on inferential reasoning task performance. Journal of Personality and Social Psychology, 55, 499-505.

Deffenbacher, J. L. (1978). Worry, emotionality, and task-generated interference in test anxiety: An empirical test of attentional theory. Journal of Educational Psychology, 70, 248-254.

Desvousges, W. H., & Cox, J. A. (1986). Radon focus groups: A summary. Report, Research Triangle Institute. Research Triangle Park: NC.

Desvousges, W. H., & Kollander, M. (1986). Radon focus groups: A summary. Report, Research Triangle Institute. Research Triangle Park: NC.

Desvousges, W. H., & Smith, V. K. (1988). Focus groups and risk communication: The "science" of listening to data. Risk Analysis, 8, 479-484.

Desvousges, W. H., Smith, V. K., & Rink, H. H., III. (1989). Communicating radon risk effectively: Radon testing in Maryland. Final Report submitted to the Office of Policy, Planning, and Evaluation, EPA-230-03-89-048. Washington, D. C.: United States Environmental Protection Agency.

Dickie, M., Fisher, A., & Gerking, S. (1987). Market transactions and hypothetical demand data: A comparative study. Journal of the American Statistical Association, 82, 69-75.

Dillman, D. A. (1978). Mail and telephone surveys: The total design method. New York: Wiley.

Douglas, M., & Wildavsky, A. (1982). Risk and culture. Berkeley, CA: University of California Press.

Doyle, J. K., Elliott, S. R., McClelland, G. H., Russell, G. W., & Schulze, W. D. (1989). An evaluation of policies for solving the radon problem. Boulder, CO: University of Colorado, Boulder, May.

Eagly, A. H. (1981). Recipient characteristics as determinants of responses to persuasion. In R. E. Petty, T. M. Ostrom, & T. C. Brock (Eds.), Cognitive responses in persuasion (pp. 173-195). Hillsdale, NJ: Erlbaum.

Edelstein, M. R., & Boyle, V. (1986). Media and the perception of risk. In W. Makofske and M. Edelstein (Eds.), Radon and the environment (pp. 233-240). Mahwah, N. J.: Instute for Environmental Studies, Ramapo College of New Jersey.

Ferguson, M. A., & Valenti, J. M. (1988). Risk-taking tendencies and radon messages: A field experiment testing an information processing model for risk communication. Paper presented to Mass Communication and Society Division, Association for Education In Journalism and Mass Communication, Portland, Oregon, July.

Ferguson, M. A., Valenti, J. M., & Melwani, G. (1988). Effects of adventurousness, impulsiveness, & rebelliousness on health and environmental risk-taking attitudes. Paper submitted to International Communication Association, Health Communication Division, November 1.

Fischhoff, B., & Beyth, R. (1975). "I knew it would happen" - remebered probabilities of once-future things. Organizational Behavior and Human Performance, 13, 1-16.

Fischhoff, B., Slovic, P., Lichtenstein, S., Read, S., & Combs, B. (1979). How safe is safe enough? A psychometric study of attitudes towards technological risks and benefits. Policy Sciences, 9, 127-152.

Fishbein, M., & Ajzen, I. Belief, attitude, intention and behavior. Reading, Mass.: Addison-Wesley.

Fisher, A., & Sjöberg, L. Radon risks: People's perceptions and reactions. In Majumdar, Schmalz & Miller (Eds.), Environmental radon: Occurrence, control and health hazards. Pittsburgh: Pennsylvania Academy of Science, in press.

Fisher, A., Chestnut, L., & Violette, D. M. (1988). The value of reducing risks of death: A note on new evidence. Journal of Policy Analysis and Management, 8, 88-100.

Florig, H. K., & Morgan, M. G. (No date). A simulated house for learning about radon. Pittsburgh, Pa: Carnegie Mellon University, Department of Engineering and Public Policy.

Freudenberg, W. R. (1988). Perceived risk, real risk - social science and the art of probable risk assessment. Science, 242, 44-49.

Guimond, R., Elliott, W., Fitzgerald, J., Windham, S., & Cumy, P. (1979). Indoor radiation exposure due to Radium-226 in Florida Phosphate lands. Washington, D. C.: Environmental Protection Agency, July.

Hileman, B. (1988). Fluoridation of water. Chemical and Engineering News, 66(31), 26-42.

Isen, A. M., Means, B., Patrick, R., & Nowicki, G. (1982). Some factors influencing decision making strategy and risk taking. In M. S. Clark & S. T. Fiske (Eds.), Affect and cognition (pp. 243-261). Hillsdale, NJ: Erlbaum.

Janis, I. L. (1962). Psychological effects of warnings. In G. W. Baker & E. W. Chapman (Eds.), Man and society and disaster. New York: Basic Books.

Janis, I. L. (1982). Stress, attitudes, and decisions. New York: Praeger Books.

Janz, N. K., & Becker, M. H. (1984). The health belief model: A decade later. Health Education Quarterly, 11, 1-47.

Johnson, E., & Tversky, A. (1983). Affect, generalization and the perception of risk. Journal of Personality and Social Psychology, 45, 20-31.

Johnson, F. R., & Fisher, A. (1989). Conventional wisdom on risk communication and evidence from a field experiment. Risk Analysis, 9, 209-213.

Johnson, F. R., & Luken, R. A. (1987). Radon risk information and voluntary protection: Evidence from a natural experiment. Risk Analysis, 7, 97-107.

Johnson, F. R., Fisher, A., Smith, V. K., & Desvousges, W. H. (1988). Informed choice or regulated risk? Lessons from a study in radon risk communication. Environment, 30(4), 12-35.

Johnson, R. (1987). Radon control policies in Sweden: A status report. EPA Document 870722.

Kerr, R. A. (1988). Indoor radon: The deadliest pollutant. Science, 240, 606-608.

Klotz, M. L., Weinstein, N. D., & Sandman, P. M. (Undated). Promoting remedial response to the risk of radon: Are information campaigns enough? Unpublished paper.

Krimsky, S., & Plough, A. (1988). Environmental hazards: Communicatings risks as a social process. Dover, Massachusetts: Auburn.

Krosnick, J. A. (1988). The role of attitude importance in social evaluation: A study of policy preferences, presidential candidate evaluations, and voting behavior. Journal of Personality and Social Psychology, 55, 196-210.

Krosnick, J. A., & Schuman, H. (1988). Attitude intensity, importance, and certainty and susceptibility to response effects. Journal of Personality and Social Psychology, 54, 940-952.

Kunda, Z. (1987). Motivated inference: Self-serving generation and evaluation of causal theories. Journal of Personality and Social Psychology, 53, 636-647.

Kunreuther, H., Ginzberg, R., Miller, L., Sagi, P., Slovic, P., Borkan, B., & Katz, N. (1978). Disaster insurance protection: Public policy lessons. New York: Wiley.

Lafore, M. (1987). Radon. The invisible threat. Emmaus, Pa: Rodal Press.

Lau, R., Kane, R., Berry, S., Ware, J., & Roy, D. (1980). Channeling health: A review of the evaluation of televised health campaigns. Health Education Quarterly, 7, 56-89.

Lehman, D. R., & Taylor, S. E. (1987). Date with an earthquake: Coping with a probable, unpredictable disaster. Personality and Social Psychology Bulletin, 13, 546-555.

Lehrer, B. (1988). The radon response: A literature review and discussion. Risk Assessment and Risk Management, 1988.

Leventhal, H. (1970). Findings and theory in the study of fear communications. In L. Berkowitz (Ed.), Advances in social experimental psychology, Vol. 5. New York: Academic Press.

Leventhal, H. (1986). Health psychology: A social psychological perspective. In L. Berkowitz (Ed.), A survey of social psychology (3rd ed.), (pp. 448-476). New York: Holt, Rinehart & Winston.

Magat, W. A., Payne, J. W., & Brucato, Jr., P. F. (1986). How important is information format? An experimental study of home energy audit programs. Journal of Policy Analysis and Management, 6, 20-34.

Maher, E. F. (1988). Characterization and control of Radon-222 and its progeny in buildings. Aviation Space and Environmental Medicine, 59(11), Section II, A93-A99.

Makofske, W., & Edelstein, M. (Eds.) (1987) Radon and the environment. Mahwah, NJ: Ramapo College.

Mazur, A. (1981). The dynamics of technical controversy. Washington, DC: Communications Press.

Mazur, A. (1984). The journalists and technology: Reporting about Love Canal and Three Mile Island. Minerva, 22, 45-66.

Mazur, A. (1987). Putting radon on the public's risk agenda. Science, Technology, & Human Values, 12, 86-93.

Mazur, A. (No date). Does public perception of risk explain the social response to potential hazard? Quarterly Journal of Ideology,

Mazur, A., & Hall, G. (No date). Effects of social influence and objective risk on response to radon. Unpublished manuscript.

McGuire, W. J. (1985). Attitudes and attitude change. In G. Lindzey & E. Aronson (Eds.), The Handbook of Social Psychology. Vol. 2. 3rd Ed. (pp. 233-304). New York: Random House.

Mileti, ,D., & Sorensen, J. H. (1987). Natural hazards and precautionary behavior. In N. D. Weinstein (Ed.), Taking care: Understanding and encouraging self-protective behavior. New York: Cambridge University Press.

Miller, S. M. (1980). When is a little information a dangerous thing? Coping with stressful life-events by monitoring vs. blunting. In S. Levine & H. Ursin (Eds.), Coping and health (pp. 145-169). New York: Plenum Press.

Miller, S. M., Brody, D. S., & Summerton, J. (1988). Styles of coping with threat: Implications for health. Journal of Personality and Social Psychology, 54, 142-148.

Mischel, W. (1973). Toward a cognitive social learning reconceptualization of personality. Psychological Review, 80, 252-283.

National Research Council, Committee on the Biological Effects of Ionizing Radiation (1988). Health effects of radon and other internally deposited alpha-emitters (BEIR IV). Washington, D. C.: National Academy Press.

Nero, A. (1989). Earth, air, radon and home. Physics Today, 42(4), 32-39.

Office of Radiation Programs, US Environmental Protection Agency (1986). Press release, August 14.

Parducci, A., & Perrett, L. F. (1971). Category rating scales: Effects of relative spacing and frequency of stimulus values. Journal of Experimental Psychology, 89, 427-452.

Perloff, L. S. (1983). Perceptions of vulnerability to victimization. Journal of Social Issues, 39, 41-61.

Petty, R. E., & Cacioppo, J. T. (1981). Attitudes and persuasion: Classic and contemporary approaches. Dubuque, Iowa: Brown.

Petty, R. E., & Cacioppo, J. T. (1986). The elaboration likelihood model of persuasion. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol. 19) (pp). New York: Academic Press.

Puska, P., Tuomilehto, J., Salonen, J., Neittaanmaki, L., Maki, J., Virtamo, J., Nissinen, A., Koskela, K., Takalo, T. (1979). Changes in coronary risk factors during a comprehensive five-year community program to control cardiovascular diseases (North Karelia Project). British Medical Journal, 2, No. 6198, 1177-1178.

Radon Risk Communication Project. (1987). Interim Report. Washington, D. C.: United States Environmental Protection Agency, Office of Policy, Planning and Evaluation.

Rogers, R. W. (1983). Cognitive and psychological processes in fear appeals and attitude changes: A revised theory of protection motivation. In J. T. Cacioppo and R. E. Petty (Eds.), Social psychophysiology. Boston: Reidel.

Rogers, R. W. (1987). Cognitive and physiological processes in fear appeals and attitude change: A revised theory of protection motivation. In J. T. Cacioppo & R. E. Petty (Eds.), Social Psychophysiology (pp. 153-176). New York: Guildford Press.

Rotblat, J. (1988). A tale of two cities. New Scientist, 117(1594), 46-50.

Sandman, P. (1986). Explaining environmental risk. Some notes on environmental risk communication. Washington, D. C.: United States Environmental Protection Agency, Office of Toxic Substances.

Sandman, P. M., Weinstein, N. D., & Klotz, M. L. (1987). Public response to the risk from geological radon. Journal of Communication, 37, 93-108.

Schneider, W., & Shiffrin, R. M. (1977). Controlled and automatic information processing:I. Detection, search and attention. Psychological Review, 84, 1-66.

Seven Cardinal Rules of Risk Communication. (1988). Washington, D. C.: United States Environmental Protection Agency.

Sharlin, H. I. (1987). EDB: A case study in the communication of health risk. In B. Johnson & V. Covello (Eds.), The social and cultural construction of risk. Boston: Reidel.

Short, Jr., J. (1984). Toward the social transformation of risk analysis. American Sociological Review, 49, 711-725.

Silver, M., & Sabini, J. (1981). Procrastinating. Journal for the Theory of Social Behaviour, 11, 207-221.

Sjöberg, L. (1979). Strength of belief and risk. Policy Sciences, 11, 39-57.

Sjöberg, L. (1980). Volitional problems in carrying through a difficult decision. Acta Psychologica, 45, 123-132.

Sjöberg, L. (1985). Motivation and compliance: How assessed, how important. In J. Hirsch & T. B. Van Itallie (Eds.), Recent Advances in Obesity Research IV (pp.275-280). London: John Libbey.

Sjöberg, L., & Biel, A. (1983). Mood and belief-value correlation. Acta Psychologica, 53, 253-270.

Sjöberg, L., & Drottz, B.-M. (1987). Psychological reactions to cancer risks after the Chernobyl accident. Medical Oncology and Tumor Pharmacotherapy, 4, 259-271.

Sjöberg, L., & Drottz, B.-M. (1988). Radiation risks: Knowledge and subjective experience among nuclear power plant employees. Paper read at the Annual Meeting of the Society for Risk Analysis, October 30 - November 2, 1988, Washington, D.

Sjöberg, L., & Winroth, E. (1986). Risk, moral value of actions, and mood. Scandinavian Journal of Psychology, 27, 191-208.

Slovic, P., & Lichtenstein, S. (1971). Comparison of Bayesian and regression approaches to the study of information processing in judgment. Organizational Behavior and Human Performance, 6, 649-744.

Slovic, P., Fischhoff, B., & Lichtenstein, S. (1981). Characterizing perceived risk. In R. W. Kates & C. Hohenhemser (Eds.), Technological hazard management. Cambridge, Mass.: Oelgeschlager, Gunn & Hain.

Smith, V. K., & Johnson, F. R. (1988). How do risk perceptions respond to information? The case of radon. The Review of Economics and Statistics, 70, 1-8.

Smith, V. K., Desvousges, W. H., & Fisher, A., & Johnson, R. (1987). Communicating redon risk effectively: A mid-course evaluation. EPA-230-07-87-029.

Smith, V. K., Desvousges, W. H., Fisher, A., & Johnson, R. (198[redacted] Learning about radon's risk. Journal of Risk and Uncertainty, 1, 233-258.

Smith, V. K., Desvousges, W. H., Johnson, F. R., & Fisher, A. (1988). Can public information programs affect risk perception? Paper submitted for publication.

Sorrentino, R. M., & Hancock, R. D. (1987). The role of information and affective value for social influence: A case for the study of individual differences. In M. P. Zanna, J. M. Olson, & C. P. Herman (Eds.), Social influence: The Ontarior Symposium (Vol. 5, pp. 244-268). Hillsdale, NJ: Erlbaum.

Sorrentino, R. M., Bobocel, D. R., Gitta, M. Z., Olson, J. M., & Hewitt, E. C. (1988). Uncertainty orientation and persuasion: Individual differences in the effects of personal relevance on social judgments. Journal of Personality and Social Psychology, 55, 357-371.

Sorrentino, R. M., Short, J., & Raynor, J. O. (1984). Uncertainty orientation: Implications for affective and cognitive views of achievement behavior. Journal of Personality and Social Psychology, 46, 189-206.

Stallen, P. J. M., & Thomas, A. (1988). Public concern abo[redacted] industrial hazards. Risk Analysis, 8, 237-245.

Swedish National Institute for Radiation Protection (1987). Radon i bostäder. SSI-rapport 87-17. Stockholm, Sweden: Statens strålskyddsinstitut.

Tesser, A. (1978). Self-generated attitude change. In L. Berkowitz (Ed.), Advances in experimental social psychology (Vol.11, pp. 289-338). New York: Academic Press.

Tufte, E. R. (1983). The visual display of quantitative information. Cheshire, CT: Graphics Press.

U.S. Environmental Protection Agency (1986). Radon reduction methods: A home owner's guide. OPA-86-005. Washington, D. C.: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (1987 a). Evaluating and improving EPA's risk advisory programs. Washington, D. C.: U.S. Environmental Protection Agency, Program Evaluation Division.

U.S. Environmental Protection Agency (1987 b). Radon risk communication project. Interim report. Washington, D. C.: U.S. Environmental Protection Agency, Office of Policy, Planning & Evaluation.

U.S. Environmental Protection Agency (1987 c). Unfinished business: A comparative assessment of environmental problems. Washington, D. C.: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency (1988 a). Region 3/OPPE/State of Maryland Radon Risk Communication Project: An Evaluation of Radon Risk Communication Approaches. Washington, D. C.: U.S. Environmental Protection Agency, Office of Policy, Planning, and Evaluation, Program Evaluation Division.

U.S. Environmental Protection Agency (1988 b). Seven Cardinal Rules of Risk Communication. Washington, D. C.: U.S. Environmental Protection Agency.

U.S. Environmental Protection Agency and Centers for Disease Control (1986). A citizen's guide to radon: What it is and what to do about it. OPA-86-004. Washington, D. C.: U.S. Environmental Protection Agency.

Unger, D., & Wandersman, A. (1985). The importance of neighboring: The social, cognitive, and affective components of neighboring. American Journal of Community Psychology, 13, 139-169.

United Nations Scientific Committee on Effects of Atomic Radiation. (1977). Sources and effects of ionizing radiation. New York: United Nations.

Valenti, J. M., & Ferguson, M. A. (1987). Radon awareness, concern, responsibility, and source confidence: A survey of home-owners in three Florida counties--Alachua, Hillsborough & Polk. Unpublished manuscript. Gainsville, FL: University of Florida, College of Journalism and Communications.

Valenti, J. M., & Ferguson, M. A. (No date). Risk-taking tendencies and radon messages: A field experiment. Paper No. II-P4. University of Florida, Communication Research Center, College of Journalism and Communications.

Viscusi, W. K., Magat, W. A., & Huber, J. (1986). Informational regulation of consumer health risks: An empirical evaluation of hazard warnings. Rand Journal of Economics, 17, 351-365.

Wallsten, T. S., & Budescu, D. V. (1983). Encoding subjective probabilities: A psychological and psychometric review. Management Science, 29, 151-173.

Wallston, B. S., Wallston, K. A., Kaplan, G., & Maides, S. A. (1976). Development and validation of the Health Locus of Control (HLC) Scale. Journal of Consulting and Clinical Psychology, 44, 580-585.

Weinstein, N. D. (1980). Unrealistic optimism about future life events. Journal of Personality and Social Psychology, 39, 806-820.

Weinstein, N. D. (1984). Why it won't happen to me: Perceptions of risk factors and susceptibility. Health Psychology, 3, 431-457.

Weinstein, N. D. (1987). Unrealistic optimism about susceptibil to health problems: Conclusions from a community-wide samp Journal of Behavioral Medicine, 10, 481-500.

Weinstein, N. D. (1988). The precaution adoption process. Health Psychology, 7, 355-386.

Weinstein, N. D., Klotz, M. L., & Sandman, P. M. (1988). Optimistic biases in public perceptions of the risk from radon. American Journal of Public Health, 78, 796-800.

Weinstein, N. D., Sandman, P. M., & Klotz, M. L. (1987). Public response to the risk from radon, 1986. Final Report. Rutgers, The State University of New Jersey: Cook College.

Weinstein, N. D., Sandman, P. M., & Roberts, N. E. (Undated). Determinants of self-protective behavior: Home radon testing. Unpublished. Rutgers, The State University of New Jersey: Cook College.

Weinstein, N. D., Sandman, P. M., & Roberts, N. E. (1988). Homeowner radon mitigation. Report to the Division of Environmental Quality, New Jersey Department of Environmental Protection.

Weinstein, N. D., Sandman, P. M., & Roberts, N. E. (1989). Communicating effectively about changes in risk. Final Repo to the Office of Policy Analysis, U.S. Environment Protection Agency.

Wicker, A. W. (1969). Attitudes vs. actions: The relationship of verbal and overt behavioral responses to attitude objects. Journal of Social Issues, 25, 41-78.

Wiio, J., Puska, P. Koskela, K., & McAlister, A. (1986). Television in national health promotion in Finland: The 'Keys to health' TV program in 1982. In D. S. Leathar, G. B. Hastings, K. O'Reilly & J. K. Davies (Eds.),

Zuckerman, M. (1988). Behavior and biology: Research on sensation seeking and reactions to the media. In L. Donohew, H. E. Sypher, & E. T. Higgins (Eds.), Communication, social cognition, and affect (pp. 173-194). Hillsdale, NJ: Lawrence Erlbaum Associates.

APPENDIX

COMMUNICATING RADON RISK.

Practical implications of recent research findings

This appendix provides a summary of principles of effective risk communication applied to radon risk, based on current research.

The basic principles of good communication are a first step for successful communication of radon risk. Guidance on these principles is readily available elsewhere (e.g EPA's "Seven Cardinal Rules of Risk Communication").

Research on persuasion and attitude change has shown that it is difficult to change attitudes and even more difficult to change behavior. Knowledge is easier to communicate but knowledge is by no means sufficient to cause a change in behavior or attitudes. Fortunately, it has still been found that skillful and enthusiastic attempts at communication of radon risks have had some success.

People often have biased perceptions of risks. They may dismiss or exaggerate them, depending on many factors. Unlike such risks as nuclear power or toxic wastes, the largest problem with radon is that people tend to dismiss or deny the risk.

There are several reasons why people tend to deny and dismiss radon risk:

- the risk is associated with one's home which is usually perceived as a source of security and as part of one's identity.

- acknowledging the risk carries with it both economic and psychological costs: it requires testing and possibly costly mitigation, and also worry about health effects.

- adverse effects will not show up for a long time, and people are more concerned about the short run.

- the risk is perceived as natural rather than man-made.

The objective of any radon risk communication program should be to arouse - but not alarm - people and motivate them to take appropriate action. The following points can help in designing such a program:

1. People are more likely to acknowledge and act on a risk if they (a) see it as a serious threat, and (b) perceive that measures to mitigate the risk exist and are within their reach. Both these points must be formulated clearly. First, people need to be aware of the risk. Radon cannot be perceived with the senses, and its effects, if any, are delayed. People need to be informed that even if they have already been exposed to radon for a long time, it is never too late to mitigate since the body can repair some damage if exposure is decreased so any reduction in exposure reduces risks. Make them aware that test kits are easy to get and

inexpensive. Try to diminish fears that mitigation is ve[redacted] expensive and complicated.

This suggests the following strategy:

A. Raise awareness: "Say, have you heard about Radon? It is a colorless and odorless radioactive gas that seeps into some homes and can cause lung cancer".

B. "It is easy to find out whether your home has dangerous radon levels - testing is inexpensive and you can get a do-it-yourself test kit at your nearby hardware store, supermarket, or discount store."

C. "You can stop worrying if your radon level is low. If it is high, mitigation is affordable and effective."

D. "What if you have already been living for a long time in a house with high radon levels?" (Provide material about lungs repairing damage).

E. "But I only plan to live here for a few years, at the most. Why should I mitigate?" (Point out that mitigation apparently protects resale value - however, there is little research yet on this problem. Point out that mitigation is a way of protecting one's investment in a house, and a way of avoiding unpleasant surpris[redacted] when selling it).

2. People frequently dismiss potential hazards when it comes to their own personal risk, yet accept that others, unrelated to them but otherwise similar, are at risk. This tendency may be enhanced when the probability is small (say, less than 0.1) or uncertain. Sometimes these difficulties may be avoided by accumulating risks over a longer time period or by framing them in appropriate terms, e. g., the number of people in the community likely to develop lung cancer from a given level of radon exposure.

3. People dislike uncertainty and may use it as an excuse for disregarding a risk message that indicates a lack of complete understanding of a risk or conflicts among experts. Of course, honesty is essential. The best strategy is to formulate the message that although experts do not have a complete understanding of all issues involved, they do agree about important practical conclusions.

4. Because it is hard to understand probabilities, people prefer safety thresholds. They dislike being faced with a complex decision involving trade-offs between various value dimensions that are difficult to compare. Many people like to have someone they trust make a difficult decision for them or to be advised according to a simple rule of the kind "act if value exceeds x". This means tha[redacted] EPA's action guidelines will often be treated as safety standards.

5. Personalized risks, i. e. messages that are concrete and vivid and that depict people with whom one can identify, are essential.

6. Direct social influence from friends and neighbors is probably the most powerful way of affecting behavior. However, it is not easy to initiate such a process and, in the case of radon, people may be unwilling to tell others about their experiences. One tactic that has worked is for community leaders to support the testing program by publicizing tests of their own homes and to encourage others to test. Try to encourage people who have tested and mitigated to tell their friends and neighbors about their experience. It should be seen as a smart and sensible thing to do. It may help to associate testing with scientific and technological advances.

7. There is some evidence that too little information may make some people unnecessarily anxious about radon risk. Too much information may, on the other hand, be detrimental because it is too much to absorb. People are exposed to an enormous amount of mass media information. The obvious conclusion is that it is important to formulate complete, but concise, messages.

8. Use as many media channels as possible. Design the message so as to attract attention, make it concrete and repeat it often. A utility bill flyer had encouraging results. Posters required considerable effort to place. Effectiveness of PSA's on radio has been difficult to judge. EPA has produced a slide show, including an audio tape and script. It is available through the Radon Office, phone 202/475-9605.

9. Research has shown that people are especially averse to <u>certain losses</u>. Here is a strategy that takes advantage of that tendency:

"Are you worried about what radon may do to you and your family? Radon risk is one worry you can get rid of! A radon test of your home will either relieve you of all future worry over the issue - a likely outcome - or it will be the first step in permanently removing a threat to you and your family".

This gives a positive message rather than a negative one, while doing nothing leaves one more thing to worry about.

10. Some data suggest that women are more likely to carry out testing than men, and that they are particularly concerned about their children's health so work especially with women and emphasize that testing for radon is very easy and requires no special technical skill.

11. As pointed out earlier, information campaigns for motivating voluntary changes in behavior are likely to have limited success. Legislation has often turned out to be necessary in order to make a difference, as in the case of seatbelt use in automobiles. Effective reduction of radon risks may involve

(a) requiring construction techniques that reduce likely infiltration of radon; and

(b) requiring testing at the time of a real estate sale, probably after the buyer takes possession to avoid inaccurate low readings.

Summing up, we conclude that risk communication is difficult but by no means impossible. Important results have been achieved, and the principles discussed here have shown promise in practical applications. Further results are expected from on-going research, especially on mitigation behavior.