Strategies for Promoting Radon Mitigation: A Literature Review

Introduction

Once people have tested their homes for radon and received results indicating that their radon level is above the Environmental Protection Agency's (EPA's) action guideline of 4 pCi/l, what types of messages and programs increase the likelihood that they will take action to reduce their exposure? Social scientists, marketers, and program managers have examined how people perceive the radon threat, how to effectively communicate with the public about the risks they face from radon and what types of programs result in increased rates of mitigation. This document summarizes some of the lessons learned.

The lessons are more meaningful if they are considered in light of the factors that influence people's mitigation decisions. Patterns that emerge across numerous studies indicate that these are: (Aceti, 2006)

Perceived Seriousness of Radon Level. The more that people perceive the radon level in their home to be dangerous or to be a serious problem, the more likely they are to mitigate.

Actual Radon Level. People are more likely to mitigate when higher levels of radon are present in their home.

Relationship between Perceived Risk and Actual Risk. Many studies that examine the factors influencing people's mitigation decisions look at whether people are accurately perceiving the risk they face from the radon in their home. Researchers have found that correlations between perceived and actual risk range from non-existent to moderate. Studies have also found that people tend to underestimate their risk. That is, they have an "optimistic bias."

Cost. Those who do not mitigate the high radon levels in their homes often cite the expense of carrying out mitigation actions.

Confusion about Mitigation techniques. Uncertainty about the most appropriate mitigation method for their home, fear of exploitation and difficulty obtaining information on remediation are barriers to mitigation.

Lack of Time. Some people do not act because they are too busy to make the necessary arrangements for radon mitigation.

Difficulty Interpreting Technical Information. Many people have difficulty interpreting their radon test results, especially because the units in which they are reported, picocuries per liter of air, are unfamiliar to most people.

Belief about Effect on Property Value. Beliefs that radon mitigation would reassure or would deter potential buyers influence decisions about mitigation action.

This document is divided into four parts.

Part I. Threat Perception. This section describes aspects of how people generally assess risks that they face, as well as characteristics of the radon hazard that affect how people perceive it.

Part II. Communicating Radon Risk. This section reports on a body of research that explores the most successful ways to communicate with the public about the risks from radon.

Part III. Strategies for Promoting Mitigation. This section first seeks to establish benchmarks for successful initiatives to promote radon mitigation. It then reports on several programs that were tested for effectiveness in motivating homeowners to reduce high radon levels. It also outlines strategies that European Union countries have found effective in promoting radon mitigation.

Part IV. Strategies for Promoting Mitigation During Real Estate Transactions. This section provides suggestions on realizing the

potential for promoting radon mitigation in the context of real estate transactions.

Ideally, each of the communication and programmatic strategies presented here would have been evaluated through rigorous experimentation to determine if it has statistically significant effects on risk perceptions or mitigation rates. However, the amount of quantitative research available is limited. Therefore, some of the research cited here is qualitative. It relies on focus group research, or the accumulated experience of practitioners at agencies charged with promoting radon testing and mitigation. Quantitative research may provide stronger evidence of what works. However, guidance that comes from accumulated experience or from target audience members themselves may also be of value as practitioners work to identify best practices.

It is also preferable to look for patterns across numerous studies indicating that a particular risk communication technique or campaign strategy is effective in promoting radon mitigation. However, in evaluating methods for promoting mitigation, researchers often examined very different approaches. It is rarely possible to determine whether a particular strategy proved effective across studies. Where either confirmatory or contradictory evidence exists, it is noted.

Part I. Threat Perception

There are numerous barriers to the perception of radon as a hazard. The challenges of communicating radon risk may be partly due to the fact that many characteristics of this hazard lead people to underestimate or to dismiss its risk. (Doyle, et. al., 1991, p121)

Radon is a Voluntary Risk

While experts typically judge risk in terms of the probability of harm, members of the public commonly have a more complicated view of risk that includes such factors as whether the risk is controllable or uncontrollable, voluntary or involuntary, natural or technological. (Doyle, et. al., 1990, p120) The public is more alarmed about risks that are controlled by others, such as pesticides on food or hazardous waste dumps, than with risks that require individual action to be eliminated, such as radon. As a result, the public tends to see involuntary risks as more serious, when in fact, voluntary risks are often more substantial.

Radon is underestimated even though the concept of radiation normally evokes considerable concern in the public. Consider the fear engendered by radioactive waste sites. However, a radiation threat as potentially serious as radon leaves people apathetic. Research shows that this is because, radon, unlike other environmental problems that receive more attention from the public, is mostly a voluntary risk. (Guimond & Page, 1992, p172 & 175)

Radon is a Natural Substance

People are likely to believe that natural substances are 'good' or at least 'not harmful,' especially since most other environmental problems are man-made. (Guimond & Page, 1992, p170)

People Have Difficulty Evaluating Risk

Typically, people do poorly when judging probabilities, making predictions, coping with uncertainty and, in general, thinking instinctively about risk. This is especially true for lower probability risks. For example, the objective probability of getting lung cancer as a result of a lifetime exposure to 4 pCi/l of radon (between 1 and 5% chance according to the EPA) is in the category of risks small enough that people have particular difficulty understanding the risk and responding appropriately. (Doyle, et. al., 1991, p121; Fisher, McClelland, et. al., 1991, p1441) When confronted with low probability risks, people tend to respond in either one of two ways: a complete lack of concern or overconcern. (Doyle, et. al., 1990, p121)

Radon Hazard Cues are Limited

People also evaluate risk poorly because they commonly rely on judgmental devices

that can lead to systematic biases and mistakes. For example, people often judge the likelihood that an event will happen by its "availability," that is, the ease with which instances of the event can be imagined or recalled. For a risk such as radon, availability is low. One reason is the lack of perceptual reminders of radon and its risks. (Doyle, et. al., 1990, p120) Radon is invisible, odorless and tasteless. (Fisher & Johnson, 1990, p739) No dead bodies can be directly tied to radon since it's impossible to identify specific instances of lung cancer that have been caused by it. "If radon is such a big problem, why haven't I heard about a large number of deaths?" people say to themselves. (Weinstein, et. al., 1989; Guimond & Page, 1992, p171) Further, fatalities occur on a one-by-one basis, which is less likely to make for memorable headlines (or any headlines at all) than a cause of death such as a plane crash that kills a large number of people at one time. (Foster, 1993)

Availability is also low for the radon risk because the risk occurs in people's homes, with which their prior experience is benign. People feel their homes are comfortable and non-threatening to their families. (Guimond & Page, 1992, p171) Further, fatalities from radon-induced lung cancers are delayed in time, not immediate as in a house fire. (Foster, 1993.) The delay makes the link between radon and illness harder to perceive.

People Have a 'Worry' Budget

Psychologists believe that people may have a 'worry budget.' They are willing or able to deal with only a limited number of fears at one time. Radon must compete for attention with other concerns, and its characteristics make it seem less frightening than other hazards. (Fisher & Johnson, 1990, p739) This is likely to be true in terms of people's lives in general, but it is also true of cancer in particular. Many things can cause cancer. People are tired of hearing about all of the things that they need to be concerned about. They are saturated with news and information on cancer-causing agents and tend to tune out new warnings. (Guimond & Page, 1992, p171)

Radon Characteristics that Ease Action

Experts have also pointed out some characteristics of the radon hazard that may make it easier for people to cope with than other health risks. Unlike health threats such as smoking, radon confers no positive rewards, so it is not psychologically difficult to give up. Further, reducing radon risk through mitigation is essentially a one-time action. Fisher, McClelland, et. al., 1991, p1441) In general, it is easier to encourage one-time efforts than to bring about and maintain changes in repetitive behaviors, such as eating or exercise habits. (McKenzie-Mohr, 2000, p533)

Part II. Communicating Radon Risks

In 1988, the Advertising Council accepted a request from EPA and other organizations to develop a media campaign to persuade the public to respond to the risk from radon. The Advertising Council reviewed the extensive body of radon risk communication research that had been carried out by EPA, states and academia. It also conducted its own research, which included focus groups and market studies. The major findings from this collective body of literature were summarized by R.J. Guimond and S.D. Page in an article published in 1992. They are presented below in conjunction with conclusions reached by other researchers. In some cases, it is not specified whether the findings pertain to testing, mitigation or both.

Persuasive appeals, such as concern for family, are vital to overcoming denial --

Simply being told of the risks involved does not tend to move people to action. EPA's research suggests that apathy can best be overcome by using a persuasive appeal that affects people on an emotional level. EPA has found that the most effective approach has been to focus on the responsibility people

feel for protecting their family. (Guimond & Page, 1992, p172)

Avoid ambiguous information when possible – A New Jersey study showed that when people are presented with ambiguous information, they are likely to develop overly optimistic conclusions about the risk they face from radon. Media coverage in the study area had referred to a variety of factors that can influence home radon levels, including uranium concentrations in soil, soil porosity, house ventilation rates, cracks and openings in foundation walls and floors, home appliances that create reduced air pressure in basements and other topics. None of these factors can be used reliably to predict the need for remediation. Nevertheless, the survey responses indicate that people who had not tested were interpreting these ambiguous risk factors in such a way as to reach an optimistic conclusion about their own vulnerability to harm. Other survey answers indicated that the optimistic biases could not be explained away as a lack of knowledge about the radon issue. (Weinstein, Klotz & Sandman, 1988, p797, 798, 799)

Another sample of residents had tested their homes, found levels above 4 pCi/l and sought a follow-up test through the New Jersey Department of Environmental Protections Confirmatory Monitoring Program. These residents were asked, "Compared to other people who have the same radon level as you, would you say you're any more or less likely to have your health affected?" No optimistic biases appeared in the responses to this question. (Weinstein, Klotz & Sandman, 1988, p797, 798, 799) "Compared to the factors influencing household radon levels, little had appeared in the media about what might make individuals differentially susceptible to health consequences from radon," wrote the researchers. "We suspect," they continued, "that the reason why respondents did not claim that they were less likely to become ill than others at the same radon level is simply because they could not think of any way to support such claims." The conclusion drawn by the researchers is that "when risk factor information is ambiguous (in terms of which factors are most important, how factors interact, or what represents "high risk" status for a given factor), the first effects of providing such information may be to create optimistic biases about vulnerability." (Weinstein, Klotz & Sandman, 1988, p799).

Be directive, not simply informative – EPA's research and program experience have demonstrated that people are more likely to respond to messages that tell them what to do rather than just providing background information. "When required actions are not emphasized or stated clearly, the resulting uncertainty can delay or even prevent action." (Guimond & Page, 1992, p173)

For example, in the late 1980's, the New York State Energy Research and Development Authority (NYSERDA) sent different types of information materials to homeowners along with radon readings for their homes. (Smith, Desvousges and Payne, 1995, p205) A pamphlet designed with a directive tone stressed the actions recommended by EPA for four different ranges of radon levels. In contrast, a pamphlet designed with an evaluative tone encouraged individual judgment and evaluation. It listed action guidelines promulgated by the National Council on Radiation Protection and the Canadian government in addition to EPA's. It suggested that people might want to adjust the stated risks based on their length of tenure in the home and hours spent at home each day. The pamphlet also provided information on how to make those adjustments. (Smith, Desvousges, et. al., 1988, p237-238) The pamphlet with the directive tone seemed to increase the likelihood of mitigating actions. (Smith, Desvousges and Payne, 1995, p203 & 206)

However, researchers in Middlesex County, New Jersey found that providing people with action recommendations or providing them

with information on their cancer risk from radon had similar effects on mitigation intentions when exposure levels were above 4 pCi/l. Researchers sent volunteers a pamphlet about radon and an imaginary home test result. The first three pages of the brochure, containing general background information about radon and its health effects, were the same for all recipients. The last page was a chart designed to help people determine the risk posed by the assigned radon level. Volunteers received pamphlets with one of two different charts. Both charts contained an "exposure ladder" listing various radon levels (in pCi/l). The "numbers" chart included a second column showing the cancer risk from lifetime radon exposure, displayed in extra cancer deaths per 1,000 people. The "advice" chart, in contrast, had no information on the probability of extra cancer deaths. Instead, it divided the exposure ladder into four ranges, described the risk for that range in words (e.g. "Exposure to these levels is a significant risk if it extends over many years.") and stressed recommended actions for each range. (Weinstein & Sandman, 1993, p104-105)

The study revealed that at levels greater than 4pCi/l, 70% of brochure recipients in the "numbers" condition and 71% of recipients in the "advice" condition said they would take steps to reduce their risk from radon. At levels under 4 pCi/l, however, 74% of the "numbers" condition recipients continued to say they would act, compared to only 49% of those in the "advice" condition. These results show that the benefits of advice were in restraining mitigation intentions at low levels. The "advice" chart did not demonstrate an advantage over the "numbers" chart in encouraging mitigation at high levels. (Weinstein & Sandman, 1993, p113)

Not surprisingly, the actions that brochure recipients intended to take were in better agreement with EPA policy in the "advice" condition (which had specific action recommendations) than in the "numbers" condition (which did not). (Weinstein & Sandman, 1993, p105) This finding is likely to explain why fewer people in the "advice" condition expressed an intention to mitigate when the imaginary home test result they received was below 4 pCi/l. The advice for the lower of the two ranges below 4 pCi/l was that "exposure to these levels does not call for action." Mitigation action was recommended for both of the ranges above 4 pCi/l on the "advice" chart, although the recommended time frame for action was different.

However, if being directive is more effective than simply being informative, why didn't more "advice" condition volunteers express an intention to mitigate above 4 pCi/l than did "numbers" condition volunteers? One possibility is that those in the "numbers" condition couldn't think of a good excuse to say they would not act, given that each radon concentration listed was associated with an increase in cancer deaths (albeit increases of very different magnitudes depending on the exposure). Given that inaction clearly put the person and/or their family at additional risk from cancer, it may have been uncomfortable to say to the researchers, "I don't intend to act." Seemingly, it would be easier to decide that this risk was outside of your 'worry' budget if that decision were unknown to outsiders.

Personalize the radon threat with tangible, relevant comparisons – given the strong tendency for people to deny or underestimate their individual risk from radon, it is important to personalize the radon threat. One way to do this is to compare radon risks to more familiar risks, like the risks associated with X rays that are similar to radon, but which are seen as dangerous. (Guimond & Page, 1992, p173) For example, a lifetime exposure to 2 pCi/l of radon is comparable to having 200 chest x-rays per year over a lifetime. (Smith, et. al., 1988, p238) Smoking risks are a good comparison because smoking also causes lung cancer. Avoid such comparisons as the risks of skydiving or being struck by lightning

that people feel are irrelevant to their lives. (Fisher & Johnson, 1990, p739)

Explain risk magnitudes effectively -- People look for clues about how concerned they ought to be about a risk. Slight differences in the way risks are described can have a big impact on perceptions and decisions. (Johnson & Fisher, 1989, p210; Fisher & Johnson, 1990, p739)

Risk Comparisons and Numerical Probabilities—There is evidence that giving people numerical illness probabilities (i.e. risk of dying from cancer as a result of lifetime exposure to a particular radon level) along with comparisons to the risks from smoking, x-rays, etc., helps establish a more realistic perception of the hazard. (Fisher and Johnson, 1990, p739) Providing numerical probabilities improves performance on tasks involving comparing relative risks and assessing the seriousness of risk exposures. (Johnson & Fisher, 1989, p213)

For example, in New York State, providing people with numerical probabilities ***and*** risk comparisons was significantly more effective in reducing discrepancies between objective and perceived risk than providing them with risk comparisons alone. (Johnson & Fisher, 1989, p210-211)

Advice vs. Numerical Illness Probabilities – Not all studies support the conclusion that providing numerical illness probabilities improves ability to compare relative risks and assess the seriousness of risk exposures, however. Researchers looked at whether action advice and verbal descriptions of risk for four ranges of radon exposures performed better than numerical illness probabilities[1] in bringing about reactions that varied systematically with changes in objective risk. After all, the communicator wants people to be more worried at a particular radon level than at half that level. "The results show," wrote the authors, "that "numbers" condition subjects were unable to discriminate between very low and moderately low radon levels, whereas "advice" condition subjects did discriminate between these two situations. Above the action guideline, both groups discriminated equally between moderately high and very high levels." (Weinstein & Sandman, 1993, p108 & 110)

The Locational Effect -- In New Jersey, researchers experimented with vertical exposure ladders that display a variety of radon exposure levels in pCi/l, risk probabilities expressed in extra cancer deaths per 1,000 people for these exposure levels, plus comparisons to the risks of smoking at several points along the ladder. They found that people's risk perceptions can be significantly influenced by setting the scale shown on the ladder so that their risk appears near the bottom or near the top. "Often," the authors wrote, "risk communicators seek a strategy that will alert those who are being exposed to relatively high levels of the hazard in question, while reassuring those whose exposure is relatively low." One strategy to accomplish this might be to truncate the risk ladder at both ends. "A risk ladder that runs from 2-40 pCi/l," the researchers suggested, "should be simultaneously more calming to a homeowner with a 2.5 pCi/l test result and more alarming to a homeowner with 35 pCi/l than one that runs from 0.2 to 400 pCi/l." Importantly, the location of a radon level on the risk ladder also had some effect on mitigation intentions, in addition to its effect on risk perceptions. (Sandman, Weinstein and Miller, 1994, p35, 36, 38, 42-44)

It is possible that the "locational effect" is affected by the particular types of information provided on the ladder. Although the researchers manipulated the format of the risk ladder in various ways, the ladders always displayed radon levels, quantitative information (risk probabilities expressed in extra can-

[1] See the description of the Middlesex County, New Jersey study on page 5 for more information on the two formats compared in this experiment.

cer deaths per 1,000 people), plus comparisons to the risks of smoking at several points along the ladder. "It is not known how position on a purely visual ladder might affect risk perceptions," they said. (Sandman, Weinstein and Miller, 1994, p38 & p42)

"Moreover," they wrote, "it is possible that the locational effect is influenced by the particular information provided, not just for the subject's radon level, but for other levels as well. For example, subjects with a radon level high (or low) on the ladder may tend to compare their own risk with the risk presented at the opposite end of the scale; if that 'other end' risk seems substantially different, they then judge their own risk to be high (or low) by contrast. If this is what happens, then what we have interpreted as a locational effect might depend on two factors: position on the risk ladder and the risk represented at the ends of the scale. With a ladder that covered only a narrow range of risks (e.g. 5 deaths/1000 to 10 deaths /1000), subjects might not see much difference between their level and the level on the other end of the scale, diminishing the locational effect." (Sandman, Weinstein and Miller, 1994, p42)

Exposure Units—It has been suggested that expressing radon levels in Bq/m^3 rather than pCi/l may increase the likelihood that people will perceive a risk from the radon in their home. Because an exposure level expressed in Bq/m^3 is a larger absolute number than the same level expressed in pCi/l (148 Bq/m^3 = 4pCi/l), it may strike people as more dangerous. (Sjoberg, 1989, p77). However, Sandman, Weinstein and Miller found no difference in the risk that people perceived whether radon levels were expressed in Bq/m^3 or pCi/l. (Sandman, Weinstein and Miller 1994, p43)

Frame Messages Carefully -- Knowledge from decision theory can be used to present or "frame" risks more persuasively. "Framing refers to the way the risk is put in context." (Fisher, 1993, p59) For example, there appears to be a fair amount of evidence that messages highlighting the losses or harm that can occur as a result of inaction are more persuasive than messages highlighting the gains or protection that result from taking action. (Mckenzie-Mohr, 1999, p90; Doyle, et. al., 1990, p120; Fisher, 1993, p59) However, the rule is not absolute. In a National Institutes of Health study, women who saw a "loss-framed" message encouraging them to get a mammogram were more likely to say they intended to be tested than women who saw a "gain-framed" ad. However, public clinic clients who read a negatively framed appeal were more likely to say they didn't want to get a hepatitis B vaccination, whereas those who read a gain-framed message were more inclined towards getting a vaccination. Pre-testing campaign messages to gauge real-world effects is advisable. (Morin, 2005, B05)

Establish credibility. The EPA suggests teaming up with other credible sources to bolster your message. For example, the EPA's 1986 radon program was jointly sponsored by the Centers for Disease Control. This collaborative message was further magnified when the Surgeon General issued a health advisory for radon. (Fisher, 1993, p61)

A survey of 1,462 residents of Perth, Australia explored how people perceived the credibility of various information sources when it came to messages about indoor air pollution, including radon. Universities and research institutes were regarded as being the most credible (average rating 4.6 on a scale from 1 to 6) while industry was viewed as being the least trustworthy. Government agencies (average rating 3.4) were rated below both doctors (4.2) and conservation and action groups (4.0) in terms of the reliability of the information they provide. "A possible explanation," the researchers wrote, "is that because universities and research institutes are perceived as independent bodies, their motivations in providing information would appear to be unbiased. In addition, they may be seen

to provide first-hand scientific information which is assumed to be accurate. By contrast, vested interest may be regarded as the main motivational force behind information provided by industry." (Dingle & Lalla, 2002, p281)

Survey respondents were also asked to rank television program types in terms of the accuracy of the health information they provide. News and science programs were ranked the highest, with an average rating of 4.8. Current affairs programs were perceived as the second most accurate, with an average rating of 4.0. Advertisements were judged the most inaccurate television source of health information, being given an average rating of 2.5. (Dingle & Lalla, 2002, p281)

Sixty-four African-Americans participated in focus group research on radon in Michigan. None of the focus group members had tested or mitigated and most knew very little about radon before the focus group sessions. In reviewing *A Citizen's Guide to Radon*, produced by EPA, the focus group participants indicated that they did not "like the fact that this is solely from the EPA." "We'd rather have multiple sponsoring agencies because then it gives it more credibility and makes it seem like it is more than just one person's point of view." (Witte, et. al., 1998, p295)

The focus group members offered the following recommendations on the types of messengers who would have credibility with African-American audiences and could contribute to effective radon awareness and reduction campaigns targeting that population.[2] (Witte, et. al., 1998, p298)

- African American celebrities
- Sports stars
- OSHA representative
- Friends/neighbors
- Councilmen/councilwomen
- Surgeon general
- Teachers
- Utility companies
- Michael Jordan
- Rappers
- American Lung Association
- American Cancer Society
- Public Health Department
- United Way
- Consumer reports
- Preachers

It appears that Perth residents were asked to rank the credibility of certain information sources, whereas the Michigan focus group participants were asked an open ended question about the sources they would find most credible. In part, this may explain why there is only limited overlap in the responses from these populations. In the absence of additional information, it would be wise to explore the perceptions of a particular target audience regarding the messengers they would find most credible.

Use Many Media Channels -- Because radon must fight for attention with other concerns and because its characteristics make it seem less of a risk than other hazards, it's particularly important to utilize as many media channels as possible. (Fisher & Johnson, 1990, p739) People seek out more information to validate what they have already heard. In the early 1990s, the U.S. Geological Survey developed a booklet on earthquake preparedness and distributed it to millions of residents in the San Francisco Bay area as a Sunday newspaper insert. In response to a survey, many people reported that they took action after reading the insert, not only because it listed concrete actions to take, but also because it reinforced things they had already heard elsewhere. (Mileti & Peek, 2002, p128)

Communicating Susceptibility and Severity – Research has shown that the more that people perceive the radon level in their home to be dangerous or to be a serious problem, the more likely they are to mitigate. African American focus group participants in Michigan

[2] Suggested distribution channels for reaching African-Americans can be found in the cited article.

were asked to evaluate existing radon campaign materials in terms of how well they communicated:

- A feeling of susceptibility to radon (their likelihood of being adversely affected);
- The severity of the threat from radon (the seriousness of the harm if they were to be affected) (Witte, et. al., 1998, p286)

The pamphlets evaluated were 1) "Radon: Something You Can Live Without," prepared by the Michigan Department of Public Health (MDPH) in collaboration with the American Lung Association and the American Cancer Society; 2) "Protecting Yourself and Your Family from Radon," American Lung Association (ALA); and 3) "A Citizen's Guide to Radon: The Guide to Protecting Yourself and Your Family from Radon," EPA and CDC. (Witte, et. al., 1998, p293, 294, 295) Comments on the three pamphlets are combined here.

Susceptibility. Participants referred to a picture in the MDPH pamphlet that "makes you feel susceptible because it shows radon seeping in through cracks in cement." They also thought that information given on the "estimated radon deaths makes you feel no one is exempt." (Witte, et. al., 1998, p293)

Many participants' impression of the ALA brochure was that "If you don't smoke, [the] brochure doesn't apply [or] make you feel susceptible." Similarly, some mentioned that it did not make them feel that they would be vulnerable unless they already had a lung disease (e.g. asthma or bronchitis). Finally, the participants said that the "1 in 15 homes" reference in the ALA pamphlet minimized risk to them (one person suggested the phrase, "one house on every block" instead). (Witte, et. al., 1998, p294)

The focus in the EPA/CDC pamphlet on the many ways that radon could come into one's home and the CDC endorsement led participants to feel very susceptible. However, the emphasis on suburban rather than urban homes appeared to lessen feelings of susceptibility. "That is to say," the researchers wrote, "participants thought that the pictures in the pamphlet were of suburban not urban life and, therefore, not as relevant to many African Americans." (Witte, et. al., 1998, p295)

Severity. Participants thought that the MDPH pamphlet emphasized that the "consequence of radon equals death," which conveyed seriousness. They also said that the "1 in 8 homes [information] conveys seriousness." Some participants thought that referring to the surgeon general in the pamphlet made radon sound serious because "[it's] serious if the Surgeon General talks about it." However, some participants said that a depiction in the MDPH pamphlet of a "cozy home [that was] peaceful," made radon seem less serious. (Witte, et. al., 1998, p293)

After reviewing the American Lung Association pamphlet, some participants remarked that having the American Lung Association as a sponsor made the problem of radon seem more serious. Others felt that relating the risk of radon to cigarette smoking, which most people are familiar with, portrayed radon as a more severe threat. Other participants thought that because the ALA pamphlet was extensive, radon seemed serious. "If it has a lot of info, it seems more serious; but [there's a] tradeoff because people don't want to read as much." In order to improve the ALA pamphlet, they suggested that it would be important to "make consequences of what happens to your lungs more clear," and state "what diseases does radon exposure cause exactly." On the other hand, bringing up the topic of radon in the soil seemed excessively alarming. Participants were concerned about the impact of children playing in sand boxes, for instance.

In reference to the EPA pamphlet, some people believed that the pictures, graphs and visuals, the EPA and CDC logos, and the statistics communicated the seriousness of the radon threat. However, other people thought that the "happy family on the cover" made the

radon problem seem less serious. (Witte, et. al., 1998, p294 & 295)

Overall, the researchers reported, "campaign materials should use real-life anecdotes with vivid pictures to increase perceived severity and susceptibility." (Witte, et. al., 1998, p301)

Other Risk Communication Recommendations -- Other recommendations offered by the Michigan focus group members for reaching an African-American audience were: (Witte, et. al., 1998, p298)

- Charts/clear visual depictions
- Emphasize death, be blunt
- Explain links to disease
- Distinguish between radon and carbon monoxide
- Use simple language
- Offer personal anecdotes/experiences to emphasize seriousness
- Information on landlord responsibility
- Information on tenant rights
- Specifically address risk to African Americans
- Address urban and rural audiences
- Emphasize short-term consequences (to prevent procrastination)
- Address why no physical symptoms (link to cancer)
- Prioritize in relation to other health problems
- Offer eye catching visuals that induce fear
- Address why no physical symptoms (link to cancer)
- Make text personable, colloquial (drop technical, scientific jargon)
- Create identifiable mascot ("Randy Radon")
- Explain why radon is now a problem (when it has been around forever)

The researchers summarized their recommendations for effective informational materials, based on input from focus group members. "Respondents requested simple, eye-catching pamphlets that used vivid imagery, fear and humor (all together). They thought that most campaign materials were too technical, too scientific and that information needed to be relayed to audiences in a clear, vivid style with a lot of pictures." (Witte, et. al., 1998, p297)

In addition to the pamphlets, focus group participants were asked for their reactions to two other types of campaign materials: trinkets (magnets, bookmarks, stickers) and children's coloring books.

A variety of trinkets were evaluated as a genre: (1) "Radon: Call or Test Your Home Today" (magnet: dog with gas mask and 1-800 number), (2) "1-800-RADON-GAS: Radon, Something You Can Live Without" (monkeys on bookmark), (3) "Radon: Get Rid of It" (magnet: pencil erasing the word *radon*). (4) "What You Don't' Know Can Hurt You: Radon" (EPA sticker with 1-800-number), (5) "Find the Family with the Radon Problem" (EPA magnet of homes of President Clinton, Gilligan, the Adams Family, and your family).

Some participants thought the trinkets would generate questions and raise awareness. Others thought that the trinkets trivialized the radon hazard and made it seem like "a joke, [it] makes you feel like it's something to laugh about and not worry about." Many focus group members thought that the trinkets needed to be more frightening to stimulate action, even suggesting adding a skull and crossbones or showing dead rats coming out of the wall. (Witte, et. al., 1998, p296)

A variety of coloring books were evaluated as a genre: (1) "Jason's Radon Adventure," Illinois Department of Nuclear Safety; (2) "The Radon Student Activity Book," Arizona Radiation Regulatory Agency and the Arizona Department of Real Estate; and (3) "Radon Awareness Coloring Book," American Lung Association-Alabama, Huntsville-Madison Health Department.

The participants thought that children would color the coloring books but would not read them or absorb meaning from what they were

coloring. They suggested that if one wanted to reach kids, then a video or "Sega-Genesis game on radon" would be more effective. The focus group members also thought that the coloring books would not be a good way of reaching parents because few parents interact with their children while their children are coloring. (Witte, et. al., 1998, p297)

Information Alone Rarely Leads to Behavior Change

In an evaluation of strategies for promoting radon mitigation, James Doyle and his co-authors presented recommendations applicable to radon risk communication, based upon their experience with other risk communication programs. "The major result of this experience," they say, "is that, despite an overwhelming general interest in self-protection on the part of both professionals and the public, it is enormously difficult to get specific people to perform specific behaviors in specific situations. Well-intentioned, common sense suggestions are often ineffective, and simply dispersing information and increasing knowledge is usually insufficient to motivate people to act (see also McKenzie-Mohr, D., 2000, p532). Also, people's behavior seems to be largely governed by short-term consequences, and they are very reluctant to accept definite costs in the present to prevent indefinite hardship in the future. Finally, self-efficacy, that is, a person's beliefs concerning his or her ability to perform an action and its chances for success, appears to be a very important determinant of protective behavior – attention must be paid not only to generating concern about a risk but to providing easy solutions that individuals can be confident of handling themselves." (Doyle, et. al., 1990, p123)

Guimond and Page and others echo this recommendation to **streamline the testing/mitigation process**, emphasizing that the steps have to be as simple as possible in order to be followed by a large segment of the public. (Guimond & Page, 1992, p173) People are more likely to take action if they feel they are facing a serious threat ***and*** if they feel that there are manageable ways to reduce the risk. (Fisher & Johnson, 1990, p738). In order to increase self-efficacy, Guimond and Page also suggest **emphasizing solutions to radon problems**. It is important to describe clearly how radon problems can be fixed and to address barriers to action that result from misconceptions about the cost and difficulty of remedies. "However," they say, "overstating the ease of corrective action can destroy the credibility of a program." (Guimond & Page, 1992, p173)

The African American focus group participants in Michigan were asked to evaluate existing radon campaign materials in terms of how well they communicated:

- Response efficacy (the effectiveness of available technologies in mitigating high radon levels)
- Self-efficacy (the likelihood that they themselves would be capable of carrying out mitigation) (Witte, et. al., 1998, p286)

Response Efficacy. The MDPH and ALA pamphlets appeared to communicate low response efficacy. Participants pointed out, "It just says it's fixable but doesn't say how" and it "does not address how to prevent a recurrence of the problem." One person concluded, "Knowing you have the problem isn't enough; [the] brochure does not address what you should do to fix the problem." (Witte, et. al., 1998, p293) Stating the costs of fixing the home in the ALA pamphlet appeared to produce skepticism about whether "fixing your home once [would] permanently fix the problem," or whether "it [would] be an ongoing and expensive battle." The cost issues seemed to be of great concern to people: "[I] may not be able to afford it [fixing a problem], but it is possible that you could reduce it."" (Witte, et. al., 1998, p294)

"The EPA pamphlet appeared to induce a high level of response efficacy for fixing a radon problem, in part because participants got the impression that "you can get it to accept-

able radon levels, even very high levels can be reduced to acceptable [levels]." (Witte, et. al., 1998, p295)

Self-Efficacy: Specific comments on self-efficacy applicable to mitigation were limited. The level of self-efficacy conveyed by the ALA pamphlet seemed to be relatively low. For example, "It is like you feel [that] as an individual, you do not have any power" and have no "control over the source [of the radon problem]." Others thought that the "responsibility of the individual is not reflected in the brochure." However, other participants thought that the pamphlet made them feel like they "would be able to do home repairs themselves" and that they would be able to 'look into [it] right away." Focus group members thought that the EPA pamphlet "makes people feel they can reduce radon levels" and be able to address a radon problem. (Witte, et. al., 1998, p294 & 295)

Other suggestions offered by participants for addressing response efficacy and self-efficacy concerns among African Americans were:

- Address concerns of being conned, victim of scam
- Address cost issue
- Offer subsidies for testing/fixing problem
- Offer assistance to elderly, sick, handicapped
- Show how to fix problem clearly

Summarizing their recommendations for addressing response efficacy and self-efficacy, the researchers wrote that "campaign materials must offer simple, concrete steps on how to test for radon and then on what to do if a problem emerges to increase perceived self efficacy. Second, campaign materials must clearly identify the degree to which certain radon elimination procedures work to increase perceived response efficacy." (Witte, et. al., 1998, p297 & p301)

Summary -- Communicating Radon Risk

Social scientists, marketers and program managers have explored how various techniques for communicating about radon affect risk perceptions, mitigation intentions and mitigation actions. While information alone is usually not sufficient to lead to behavior change, it is often an essential part of efforts to change behavior. Therefore, communicating effectively about radon is important. The findings presented in this section can be summarized as follows.

Emotional appeals, particularly to the sense of responsibility people feel for protecting their family, are more likely to move people to action than risk information alone.

There is evidence that people interpret ambiguous information on risk in such a way as to arrive at overly optimistic conclusions about their own vulnerability. Ambiguous information should be avoided where possible.

Experts suggest that personalizing the radon threat with tangible, relevant comparisons can help overcome the tendency for people to deny or underestimate their individual risk from radon.

Some research and program experience have demonstrated that people are more likely to respond to messages that tell them what to do rather than just providing background information. However, exceptions have also been found.

Slight differences in the way risks are described can have an impact on perceptions and decisions. There is evidence that providing people with numerical illness probabilities for various radon levels, in addition to comparisons to risks such as smoking or X-rays, helps them assess the seriousness of the risk and to compare risks of different magnitudes. However, evidence also shows that providing numerical illness probabilities does not appear to enhance performance on these tasks any more than providing verbal descriptions of risk in combination with action advice.

There is evidence that people's risk perceptions can be significantly influenced by setting the scale on an exposure ladder so that their risk falls near the bottom or near the top of a scale. Mitigation intentions are influenced as

well. Therefore, it may be beneficial to truncate the scale on radon exposure ladders so that typical high radon levels appear near the top of the ladder and typical low levels fall near the bottom.

Using a radon concentration unit such as Bq/m^3 instead of pCi/l does not appear to affect risk perceptions, even though radon levels expressed in Bq/m^3 are larger absolute numbers.

The ways that messages are framed can have an effect on their persuasive power. Messages that highlight the harm that can result from inaction have often been shown to be more persuasive than messages that highlight the protection that results from taking action. However, there are exceptions, and messages should be pre-tested to gauge their effect.

EPA's experience as well as focus group research suggests that when a message has multiple sponsors, its credibility is enhanced. Residents of Perth, Australia and African Americans living in Michigan provided some information about the types of messengers that they would find credible on the topics of indoor air pollution and radon. Because people seek out more information to validate what they have already heard, using multiple media channels to promote radon awareness and mitigation may also enhance a message's credibility.

Campaign materials should use real life anecdotes with vivid pictures to increase perceived severity and susceptibility for African American audiences. It is quite possible that these recommendations are applicable to other populations as well, although market research is always advised if feasible.

Other recommendations from African-American focus group members on radon communication can be summarized as follows: "Respondents requested simple, eye-catching pamphlets that used vivid imagery, fear and humor (all together). They thought that most campaign materials were too technical, too scientific and that information needed to be relayed to audiences in a clear, vivid style with a lot of pictures." (Witte, et. al., 1998, p297)

Trinkets such as magnets, bookmarks and stickers designed to raise awareness about radon have the potential to trivialize the radon hazard in the minds of recipients. They must be designed carefully if they are to be used. Input from focus group members indicates that neither children nor parents are likely to absorb substantive information from coloring books dealing with the radon hazard.

Despite what is known about how to make risk communication more effective, information alone rarely leads to behavior change. Research suggests that the barriers that stand between mitigation intentions and mitigation action are factors such as cost, difficulty choosing a mitigation method and lack of time. (Aceti, 2006, p9) In addition to persuading people of the risk they face from radon in their homes, it is important to provide them with manageable solutions that they feel they can implement. Experts also emphasize the need to address concerns about self-efficacy and response efficacy in communications about radon. It is important to describe clearly what needs to be done to mitigate high radon levels and to explain the degree to which various mitigation procedures can reduce exposure.

Part III. Strategies for Promoting Mitigation

The strategies described here for promoting radon mitigation include:

- a media campaign in Washington, D.C. (which also promoted testing intensively);
- a multifaceted campaign in New York State that included technical and financial assistance for homeowners in high radon homes;
- an experiment with personalized methods of delivering radon test results to residents in New Jersey; and

- activities identified by radon awareness program managers in the European Union as being effective in increasing mitigation rates.

Defining Mitigation

What types of actions taken by householders living in high radon homes constitute "mitigation?" That definition has changed considerably since radon was first identified as a health risk in the U.S in the mid 1980s. Most of the available social science research on radon testing and mitigation behavior was conducted soon after, in the late 1980s and early 1990s. In many of these studies, radon mitigation is defined as taking at least one of a number of actions. Depending on the study, the options might include limiting use of the basement, keeping windows open, actively ventilating, sealing or caulking cracks and openings, painting walls or floors, or installing air cleaners, sub slab ventilation, pressurized loft/ceiling fans, solid floor sumps or suspended floor mechanical ventilation. Every study included the installation of an active system as an option, but almost all included other options as well.

In 2007, effective radon mitigation is commonly understood to include an active system of some sort, which is a permanent modification to the building and which is installed by a professional mitigation contractor. In combination with the installation of an active system, a mitigation contractor may also take passive measures, such as sealing and caulking cracks and openings. (Morris, J., 2006)

When mitigation includes a wide range of options, from behavioral changes to building modifications of varying complexity, it is possible that the communication strategies and programs that influence people's mitigation decisions are different than when mitigation means hiring a professional contractor to install an active system. However, there are few recent peer-reviewed studies evaluating strategies to promote radon mitigation as defined in 2007. To include only the research efforts in which the definition of mitigation matches the current one would make it difficult to draw any conclusions at all. Therefore, this document includes findings from studies in which mitigation includes some options not currently considered effective.

Benchmarks for Successful Programs

What are typical mitigation rates that are achieved as a result of radon programs? What types of programs have achieved better than average results? Studies that explore the factors influencing people's mitigation decisions also collect data on people's mitigation actions. While the information provided in these studies about the programs used to promote mitigation is frequently limited, the mitigation rate among the study population is often reported. A series of summaries is offered below in order to provide a sense of the range of mitigation rates that have been observed. The number of participants involved in these studies is often quite small and therefore the degree to which these samples are representative of a larger population is unclear.

Alabama

Between 2001 and 2004, the Alabama Cooperative Extension System (ACES) and the Alabama Department of Public Health administered an array of coupon programs that offered free test kits to Alabama residents. Using contact information from the coupons, ACES surveyed those having an elevated test result to determine what actions the clients took after they received a report of a high level of radon in their home. Thirteen percent of the 83 survey respondents had mitigated high radon levels, 91% of whom had used a certified mitigator to do the work. (Roberts & McNees, 2005, p1 & 7)

NYSERDA

In the NYSERDA study described on page 4 of this document, 13% of those informed of high radon readings went on to mitigate. (Desvousges, et. al., 1989, as cited in Ford &

Eheman, 1997, p613) The 13% mitigation rate was an overall rate regardless of which type of information material was sent to a homeowner along with radon readings for their home. It appears that 41% of those who mitigated did so by increasing ventilation, but did not specify what ventilation methods were used. 7% of those who mitigated did so by opening windows or vents. 1% installed forced ventilation and 1% installed an air-to-air exchanger. In all, therefore, 50% of those who mitigated did so by increasing ventilation. 31% of those who mitigated did so by sealing cracks in the basement. 1% mitigated by installing air suction. 2% mitigated by covering exposed earth, 12% by adjusting their use of their house and 3% reduced their risk by stopping smoking. (Smith, et. al., 1995, p211)

The researchers described several aspects of the radon mitigation options for private homes that may have influenced people's mitigation decisions. "First," they say, "little was known about the effectiveness of mitigation technologies at the time of our study. Second, the availability of reliable private contractors was quite limited during the time in which our sample households made their decisions." (Smith, et. al, 1995, p208)

Boston University Medical Center Radon Testing Services

Three hundred fourteen people performed radon tests through the Boston University Medical Center Radon Testing Services (BUMC RTS) from June 1988 to May 1990. Forty-four individuals who had test results at or above 4 pCi/l were interviewed by telephone or in person. All were faculty, students or staff of Boston University Medical Center, Boston University or its affiliates. Eighteen respondents had performed a confirmatory follow-up test once their initial test results indicated a home radon level greater than 4 pCi/l. Most of the confirmatory tests were performed through the BUMC RTS. Seven respondents, or 16%, took mitigation action. All but one used sub-slab suction to reduce the radon level in their home. (Evdokimoff & Ozonoff, 1992, p215, 216)

New Jersey (a)

In a 1986 study of 138 residents from New Jersey, 10.2% of residents living in homes with radon levels of 4-20 pCi/l had either completed mitigation or were in the process of doing so. For residents living in homes with levels greater than 20 pCi/l, the figure was 53.9%. (Weinstein, et. al., 1987, as cited in Ford & Eheman, 1997, p613) The report completed by Neil Weinstein and his co-authors was not accessible, so it was not possible to determine the definition of mitigation used, or the composite mitigation rate for all households at radon levels above 4 pCi/l. However, the majority of elevated radon levels are between 4 and 20 pCi/l. In the Washington, D.C. study described later in this section, 90% of elevated radon levels were in this range. (Doyle, et. al., 1990, p17) The breakdown would vary in different parts of the country, but this figure suggests that the composite mitigation rate for households with levels above 4 pCi/l in this New Jersey study would be well under 20%.

National Health Interview Survey

In the 1990 National Health Interview Survey, respondents were asked whether they had heard of radon. Respondents who had heard of it were asked if their home had been tested for radon. Those whose homes had been tested were then questioned about whether a confirmatory test had been carried out and whether anything had been done to reduce radon exposure. Individuals who had acted to reduce their exposure were asked what specific actions had been taken. The researchers defined mitigation as physical modifications to a home. Twenty of 111 (19.8%) respondents with levels greater than 4 pCi/l had mitigated. In a subset of these homes in which confirmatory testing had been done, the mitigation rate was somewhat

higher, at 28.2%. (Ford & Eheman, 1997, p612, 613)

Conference of Radiation Control Program Directors

In a national survey of homes with radon levels greater than 4 pCi/l, in which 45,600 people participated, 23% of homes nationally and 22% of homes in high-risk areas had been remediated in 1992. (CRCPD, 1993 as cited in Ford & Eheman, 1997, p613). The original report was not accessible, so the definition of mitigation could not be determined.

Maine

Around 1986, as part of a study of the link between radon exposure and lung cancer incidence in Maine, the Maine Medical Center (MMC) tested a sample of homes and collected detailed medical histories. About half of the tested sample consisted of lung cancer and other cancer patients. The other half of the tested sample served as a control group and consisted of randomly selected individuals.

The MMC included a pamphlet developed by the University of Maine at Orono when they sent test results to households having radon exposures of more than 20,000 pCi/l for water (each 10,000 pCi/l in water corresponds approximately to one pCi/l of air exposure for an average home) or more than 3 pCi/l for air. The pamphlet was eleven pages long with various illustrations, graphs and tables. It provided extensive coverage on the source of radon, the nature of radioactive decay, the health effects of radiation, risk assessment and low-dose extrapolation problems. It provided brief coverage of the geographic distribution of the problem, relative and absolute measures of radon health risks, comparison of various existing standards for radon exposure, paths of radon infiltration in buildings and radon testing and mitigation methods. The pamphlet reported "several existing standards advocated for mining in the U.S. and Canada, for buildings in Sweden, and by the Union of Concerned Scientists, but it did not link these standards to specific mitigating actions." The pamphlet discussed several technical aspects of risk assessment but it did not attempt to guide the homeowner in assessing his risk from radon or in evaluating the probable cost of reducing exposures. The researchers noted that 24% of the full sample and 42% of respondents with a high school level education thought the pamphlet was somewhat or very difficult to understand. (Johnson & Luken, 1987, p101 & 102)

The MCC conducted telephone interviews with 221 homeowners who were exposed to more than 2 or 3 pCi/l of radon in their homes. About 51% of the whole sample (cancer patients and control group individuals combined) did something to mitigate their radon exposure. However, many interviewees reported that they took simple, low cost measures such as opening windows more frequently and avoiding basement areas. (Johnson & Luken, 1987, p101, 103-104) A rough estimate from the information in the published article indicates that about a third of the sample spent money on mitigation, which could cover anything from sealing and caulking to installation of an active system. The authors reported that the control group was significantly less likely to mitigate than households with a member who had recently been diagnosed with cancer. Johnson and Fisher (1989, p211) provide some corroborating evidence on this point, indicating that people with health concerns are more willing to pay for radon information. The study population in Maine is distinctly different than the samples used in other studies cited in this document, in that it contained cancer patients who would be expected to have a higher sensitivity to radon risks. (Johnson & Luken, 1987, p104)

New Jersey (b) and Sweden

Weinstein, et. al. (1988) reported the mitigation rate for a sample of 123 New Jersey homeowners to be 62% even for levels as low as 4-8 pCi/l. Also, Akerman (1988) reported a

mitigation rate of 38% for a sample of households with radon concentrations around 12 pCi/l in Sollentuna, a suburb of Stockholm, Sweden. (Doyle, et. al., 1991, p126) The action guideline in Sweden at the time was 10 pCi/l. Mitigation rates in Sollentuna at radon levels above 12 pCi/l were even higher. Neither the New Jersey nor the Swedish report was accessible, so it was not possible to determine the definition of mitigation used in each case. However, concern about radon began earlier in Sweden than in the USA. Alum shale was frequently used as a building material before 1975, and the initial worry was with radon emitted by building materials. (Sjoberg, 1989, p46).

Boulder County, Colorado

In 1988 and 1990, University of Colorado researchers surveyed 303[3] recent home buyers in Boulder County, CO, to determine if testing at the time of home sale had become common practice, and if such testing leads to mitigation. No extensive information or awareness campaign had been conducted in the state of Colorado as of that time, so any testing and mitigation that occurred was motivated by generally available radon information. For example, news stories indicating that Colorado had the highest percentage of homes across the country with radon levels above the EPA action guideline had appeared in the news media. (Doyle, et. al., 1990, p59 & 62)

Survey respondents were asked if they worked for IBM, which required radon testing and mitigation to below 4 pCi/l for employees in order for them to participate in the company's housing buy back program in the event they were transferred away from Boulder. IBM employees were therefore in a very different situation than non-IBM employees with respect to radon, and were analyzed separately. (Doyle, et. al., 1990, p63) "In addition," said the authors, "the fact that many real estate agents in the Boulder County area are knowledgeable about radon may be partially due to their having to deal with IBM employees as customers. The presence of such a major company with a very strict radon policy may therefore be influencing radon testing and mitigation in Boulder County even for non-IBM employees." (Doyle, et. al., 1990, p60, 62, 63 & 65)

Among 268 non-IBM homes, 36% of the 22 homes that were tested before closing and found to have levels above 4 pCi/l were confirmed mitigated (i.e. a retest was done after mitigation occurred). (Doyle, et. al., 1990, p78) Among a subset of 88 non-IBM homes whose buyers employed a realtor who gave them some information about radon, the confirmed mitigation rate for the 15 homes with tests above 4 pCi/l was 40%.

Conclusion

It is difficult to determine what constitutes a "typical" mitigation rate. The definition of mitigation is not always known, and the circumstances that could affect people's mitigation decisions are often unknown or different from case to case. Further, the numbers used to calculate the mitigation rates are often small, casting doubt on the extent to which the rates are representative of the broader population. However, an unscientific perusal of the mitigation rates presented here indicates that most measured rates tend to be below 20-25%. More recent anecdotal information is that outside of real estate transactions, mitigation rates employing contractor-installed active systems are lower than 20%, and probably below 10%. (Morris, 2007)

Details surrounding the mitigation rates of 38% or more in Sollentuna, Sweden and 62%

[3] The researchers found that those who refused to participate in the survey were often willing to answer one question: "Was your present home tested for radon before the sale closed?" The radon testing rate for these people was much lower than for the sample who did respond to the survey. Based on this information, the researchers estimated that the testing rate for all 492 homes that were called was slightly less than the testing rate for the 303 respondents. Although they were unable to assess mitigation rates for non-respondents, they speculated that there was no reason for them to be substantially lower than the rates for respondents. (Doyle, et. al.,1990, p79)

in New Jersey are not readily available. The sample studied in Maine is distinctly different than the larger population. However, the circumstances surrounding the mitigation rate of 36-40% achieved in the context of real estate transactions in Boulder County, Colorado can be examined in some detail. This mitigation rate appears to provide a higher benchmark for success, albeit with the caveat that IBM's strict radon policy may have influenced testing and mitigation even by non-IBM employees. This factor is unlikely to be replicated elsewhere. Furthermore, this mitigation rate is for homes that were retested to determine whether the mitigation effort had been successful. This constitutes a very stringent definition of mitigation. The more "typical" mitigation rates presented above and the rates achieved in Boulder County can serve as reference points in assessing the value of strategies for promoting mitigation that are described below.

Washington D.C. Media Campaign

A strategy targeting the general public was carried out in Washington D.C. in 1988. The campaign was a collaborative effort between WJLA-TV, a Washington D.C. television station, Safeway grocery stores and Air Chek, Inc., a North Carolina firm that sells and analyzes radon test kits. During the campaign (carried out in January and February of 1988), radon test kits could be purchased at 125 Safeway stores at a 50% discount or by mailing in a discount coupon that appeared in a full page, one-time advertisement in the Washington Post. In addition, the routine postage and processing fees required to obtain test results were waived by Air Chek. This promotional offer was highlighted during a consumer affairs news segment called "Radon Watch" on WJLA-TV, which launched with a three part series on January 2nd and ended with another three part series the week of February 15th. According to the A. C. Nielson company, WJLA-TV reached about 1.5 million households in Washington, D.C., Virginia and Maryland at the time. (Doyle, et. al., 1990, p15) In all, the WJLA publicity combined public service announcements, evening news coverage for a week, advertising for their special coverage and the two 'Radon Watch' series. The TV coverage repeatedly referred to the availability of test kits through the supermarkets, at a cost of $4.75 – half the usual price. (Fisher, McClelland, et. al., 1991, p1441)

Approximately 100,000 test kits were purchased during the campaign, representing about 6.5% of the target population. The study's authors indicate that this level of participation is exceptionally high for a media campaign directed at the general public. However, purchasing a test kit only rarely resulted in eventual action to reduce risk. (Doyle, et. al, 1990, p15)

Only about 56% of the test kits purchased were returned for Air Chek for analysis. This is fairly similar to a result reported for eight counties in the Appalachian and Piedmont regions of Virginia in 1992. Here, test kits were marketed though a variety of means (newspaper advertisements, television broadcasts, county fairs, Cooperative Extension newsletters, etc.). Of the 4,000 test kits sold in Virginia at $2 each, 46% were returned for analysis. (Himes, et. al., 1996) The 56% return rate experienced in the Washington D.C. campaign was substantially lower than the 90 to 95% of Air Chek test kits usually returned to the company for analysis. (Fisher, McClelland, et. al., 1991, p1441) "Apparently," the researchers speculated, "many of the people responding to the campaign are purchasing radon test kits on impulse and these people are much less likely to actually perform the test than people who purchase on their own initiative." (Doyle, et. al, 1991, p126)

All of those who returned test kits to Air Chek received a two-page letter along with their radon test results, which were reported in picocuries per liter. The letter briefly described their test results and made recommendations for follow up action that were

generally consistent with those in *A Citizen's Guide to Radon*, published by EPA. Those with exposure levels above 4 pCi/l received additional information that varied based on which of three ranges their test results fell into. Those with readings between 4 and 20 pCi/l were sent a copy of the *Citizen's Guide*. Those with readings between 20 and 50 pCi/l were sent the *Citizen's Guide* as well as another EPA publication titled *Radon Reduction Methods: A Homeowner's Guide*, (circa 1986) which described and compared nine techniques for radon reduction, ranging from low-cost natural ventilation to more expensive methods, such as forced ventilations and sub-slab suction. Those with test results above 50pCi/l received a letter urging an immediate retest accompanied by a free retest kit. (Doyle, et. al, 1990, p15-16)

A mail survey of 708 households that had purchased and returned a test kit indicated that 7.9% of those with levels above 4 pCi/l had spent money on mitigation and could describe what actions had been taken. While this criteria (termed "credible" mitigation by the researchers) excluded behavioral changes such as limiting use of the basement or keeping windows open, it is likely to include techniques that are not currently considered effective, such as relying entirely on sealing or caulking cracks and openings. The share drops further to 2.7% for those who had confirmed the effectiveness of their mitigation efforts by retesting. (Fisher, McClelland, et. al., 1991, p1442)

The study's authors speculate that the pamphlets sent with test results may have encouraged people to try their own remedial measures rather than employ a professional contractor. These home remedies were not followed by retesting to confirm their effectiveness, in spite of clear warnings that limited remedial measures were likely to be ineffective. (Doyle, et. al., 1990, p118).

The authors also reference the New Jersey(b) and Swedish studies described in the "Benchmarks" section, which documented mitigation rates of 62% and 38% or more respectively. They note that the major difference between these two studies and theirs "appears to be the amount of outside help received by testers from a government agency." (Doyle, et. al., 1990, p126) In the New Jersey(b) study, participants received free retesting and advice from the New Jersey Department of Environmental Protection's confirmatory monitoring program. In the Swedish study, initial tests were carried out by the local health department for a charge of $65, and those with a high radon reading received free retesting and mitigation advice from the department. In the Washington, D.C. study, testers received printed information produced by Air Chek and the EPA, but had no personal contact with any government agency or mitigation firm unless they initiated the contact. "Very few people seem to traverse all the steps to effective mitigation without help," the authors concluded. (Fisher, McClelland, et. al., 1991 p1443)

It is worth noting that New Jersey residents who received free retesting and advice from the New Jersey Department of Environmental Protection's confirmatory monitoring program in fact initiated requests for those services after having independently performed an initial radon test in their home and found levels above 4 pCi/l. It is possible that that the type of person who seeks out confirmatory testing is also the type of person who is more likely to follow through with mitigation.

New York State's Multi-faceted Campaign

Subsequent to 1986, New York State launched several activities to help residents reduce their risk from radon, including a public information program, a radon hotline, a radon monitoring program, a training program in radon detection and mitigation for contractors, and technical and financial assistance for people who live in homes with elevated radon levels. The radon monitoring initiative administered by the New York Department of Health (NYDOH) had been providing residents

throughout New York State with radon test kits for a small fee since 1987. Until March, 1996, the NYDOH offered aid to homeowners who qualified for the Radon Diagnostic Assistance Program. Homeowners with a confirmed short-term test result at or above 20 pCi/l in the basement or a long-term reading above 4 pCi/l in a living area, who had also carried out a home energy audit, were eligible. Eligible homeowners were provided with a list from which they could select a contractor to develop a customized mitigation plan for their house. The NYDOH would then review the plans and specifications, and approve payment of up to $300 if the plans were up to standard. (Wang, et.al, 1999, p404)

Between September 1995 and January 1996, 1,113 residents throughout the state whose homes had radon levels equal to or greater than 4 pCi/l on the first floor (or above) living areas were interviewed via telephone. In selecting interviewees, the researchers chose to over sample households with radon levels of greater than or equal to 10 pCi/l. Survey objectives included determining the percentage of homes that underwent remediation and establishing the percentage of high radon homes that were retested after mitigation was performed. (Wang, et. al, 1999, p404)

About 60% of the 1,113 residents surveyed indicated that they had taken some actions to reduce the high levels of radon in their homes. These actions included opening windows and doors, sealing or caulking cracks and openings in the basement or foundation and installing powered systems to provide more ventilation or to draw radon out from the basement. (Wang, et.al, 1999, p405 & 407) However, because people are more likely to mitigate when higher levels of radon are present in their home (including the NYDOH survey respondents), the over sampling of households with radon levels ≥ 10 pCi/l may have artificially inflated the mitigation rate. Based on information provided in the published article, it appears that the 60% mitigation rate for the interview sample translates into a 54% mitigation rate for homes with the distribution of elevated radon readings found in NYDOH's original database.

Forty-seven percent of households with elevated radon levels (corrected for over sampling) mitigated by sealing or caulking cracks and openings or by installing a system for ventilation or to draw out radon. This group of options is comparable to the definition of "credible" mitigation in the Washington, D.C. study. The share drops to roughly a 28% (corrected) confirmed mitigation rate for those who had their homes retested after mitigation was completed. (Wang, et. al, 1999, p405 & 406)

These figures are remarkably high compared to most measured mitigation rates described in the "Benchmarks" section, although the confirmed mitigation rate does not exceed that observed in the context of real estate transactions in Boulder County. The NYDOH researchers recognized that their results were quite high compared to the results reported in previous studies. They mention the National Health Interview Survey, and the Boston University Medical Center, Washington, D.C. and Maine studies specifically. They speculate that the discrepancy in mitigation rates might be partly due to the differences among the study populations. "The participants in studies published previously generally had no contact with U.S. EPA or any other government agency or mitigation firm unless they had initiated the contact," they wrote. "The survey population in this study had requested radon detectors from the NYSDOH and therefore had some exposure to the extensive public campaign programs conducted by NYSDOH." (Wang, et. al, 1999, p406)

The researchers' characterization of the cited programs does not seem entirely on target. The survey population in the Washington D.C. study had purchased a radon test kit as a result of exposure to the media campaign conducted there. The Boston University Medical Center and Maine Medical Center

study participants had performed initial and sometimes confirmatory tests through those facilities, so they had also been exposed to some sort of public information effort. However, it is certainly possible that the outreach conducted by the NYDOH was qualitatively or quantitatively different than the public information campaigns carried out in the other cases.

Seventy-seven percent of respondents who participated in the Radon Diagnostic Assistance Program administered by the NYDOH took actions to reduce radon levels in their homes, while 53% of non-participating residents took mitigation action (these figures are not corrected for over sampling). It is possible that householders with more extreme radon levels were disproportionately drawn to the program, and that more of these households would have mitigated even if the program had not existed. The published article does not provide enough information to evaluate that possibility. However, the authors suggest that the Radon Diagnostic Assistance Program was an effective mechanism for promoting radon mitigation among New York State residents. (Wang, et.al, 1999, p406 & 408)

New Jersey's Evaluation of Personalized Delivery Methods

The New Jersey Department of Environmental Protection (NJ DEP) sponsored a study to evaluate the effectiveness of three different methods of delivering radon test results to participants in the state's Confirmatory Monitoring Program. This program offered a free follow-up test to any state resident who had found a radon concentration above the 4 pCi/l action guideline when their home was tested by a private firm. (Weinstein, Roberts and Pflugh, 1992, p238)

The first delivery method was a form letter that contained little more than the action advice for each of several measurement ranges, for example: "4-8 pCi/l: Perform longer-term measurements before taking substantial remedial action." The letter was accompanied by a laboratory report that contained approximately 40 different data fields. The information of importance to the homeowner, the radon concentration, appeared at the left-hand margin near the bottom of the page. The test result was not highlighted in any particular fashion to make it stand out more clearly. Most of the people participating in the Confirmatory Monitoring program had tests in the basement and on the first floor. The form letter did not state that NJ DEP's recommendation was to follow the action advice for the highest radon level found in a used area of the home. Therefore, there was a chance that people would be puzzled about which action advice to follow if they had more than one radon test done in their home. (Weinstein, Roberts and Pflugh, 1992, p238-239)

The second delivery method was a personalized letter that integrated the homeowner's test results and corresponding action advice directly into the text, stating, when appropriate, which result came from which part of the house. DEP's action advice was based on the highest level found (normally in the basement), but homeowners were advised to consider which areas of their home they spent substantial amounts of time in, and to base their mitigation decisions on the radon level in that area. Unlike the form letter, the personalized letter urged homeowners to retest after mitigation work had been done to determine if their efforts had been effective. The personalized letters used first-person pronouns when referring to the DEP staff person who signed the letters, and an informal writing style. The letter also invited people to call if they had questions. In a postscript, the action advice for all of the five radon ranges was given, precisely as in the form letter. The recipient's address appeared in the usual location on the letter, the salutation was personalized, and the letter was signed by the DEP staff person. (Weinstein, Roberts and Pflugh, 1992, p239)

The third delivery method involved the DEP staff person sending a personalized letter ***and*** phoning the homeowner. The phone call was used to confirm that the letter had been re-

ceived and to offer assistance in interpreting the test result and action recommendations and in obtaining further information. Thirty percent of those targeted with the personalized letter/phone call combination could not be reached in person by phone. Messages were occasionally left with household members or on answering machines. (Weinstein, Roberts and Pflugh, 1992, p239 & 240)

The individuals in each experimental condition were also sent short brochures about radon risks and mitigation and lists of testing and mitigation companies. (Weinstein, Roberts and Pflugh, 1992, p239)

"The different delivery strategies had no noticeable effect on the accuracy with which respondents recalled the DEP action advice or on the extent to which they followed this advice," the researchers concluded. "In addition, there were no differences among conditions in the perception of risk, in the total amount of mitigation activity, or in the frequency of retesting after home modifications were carried out (The rate of retesting was approximately 50%)." There were small but significant differences in participant satisfaction with the program depending on the delivery method. People who had received a personalized letter and a phone call were most satisfied. People who had received the form letter along with the laboratory print out were least satisfied. (Weinstein, Roberts and Pflugh, 1992, p241-242)

The authors of the study speculated about why the personalized communication did not lead to increased rates of mitigation and retesting among those who received those communications. One reason may be that special approaches are more important for communicating more complex results (e.g. "How much of a risk is posed by chemicals found in the water sample?"). "The present message, giving one or two radon levels within a home, with a different action recommendation depending on the radon levels observed, is probably moderate in complexity," observed the authors. (Weinstein, Roberts and Pflugh, 1992, p243)

The authors also speculated that the advantages of personalized delivery strategies will sometimes be significantly greater than observed in their study. Their sample was well educated; 54% were 4-year college graduates. Although study participants with different levels of education did not show any significant differences in how they responded to the various delivery methods, the authors assert that approaches designed to help people understand test results or action advice should be more helpful with residents who are not so well educated. (Weinstein, Roberts and Pflugh, 1992, p243)

Further, in order to take part in the Confirmatory Monitoring Program, homeowners must have already obtained a radon reading on their own, must have understood that first test well enough to realize that further testing might be a good idea, and must have been motivated enough to pursue the confirmatory test. In their dealings with the private firm that carried out their first radon screening, they probably received some informational materials and may have had questions answered. Related studies of people who participate in the NJ DEP's Confirmatory Monitoring Program have shown that they are well informed about radon. The researchers speculated that "the guidance and personal assistance provided by the more ambitious delivery strategies are likely to be of greater help to people who have no previous experience with testing." (Weinstein, Roberts and Pflugh, 1992, p244)

European Union Activities

In 2003, the European Commission surveyed radon awareness program managers throughout the European Union to identify the activities that have been tried and to establish how effective they have been. The survey report did not describe what types of quantitative evidence might have been collected to support the following findings: (Scivyer, 2003)

- National campaigns are useful in introducing the radon issue and assisting with testing campaigns. "However, if progress is to be made in getting people to carry out mitigation, a local campaign is essential. Campaigns led by local government supported by national government and national experts appear to result in the biggest uptake of mitigation. ….it is the availability of local advice, guidance and technical services that encourage the uptake of mitigation."
- Local measurement campaigns that are targeted to areas with greatest risk and linked with local government public awareness campaigns have resulted in increased mitigation rates in the United Kingdom.
- A mobile exhibition unit visited 24 venues in the Banbury area of Oxfordshire, UK. Each visit lasted 2-3 hours and featured an exhibit describing radon risk and mitigation methods, together with consultations for householders who had high radon levels in their homes. Visits were scheduled to include morning, afternoon and evening sessions on three days each week to give area residents several chances to visit the exhibition. Local government personnel, supported by national radon specialists, staffed the unit. Feedback has shown that the mobile unit had a positive effect on the number of houses mitigated in the area. Events of this type that have been well attended have been accompanied by intense local publicity, including letters of invitation being sent to residents.
- Displays at shows such as County Agricultural Shows can be beneficial in raising public awareness locally, but are unlikely to have a significant impact on mitigation rates. Several radon mitigation contractors have exhibited at local shows and found them useful in gaining business.
- In Sweden, they have found that periodicals targeting homeowners or renters are very good ways to reach the public with information.
- Limited experience with formal presentations given to members of the public in the UK indicates that the more informal and locally focused the presentation, the better the response.
- The Czech Republic, Germany, the UK and Switzerland have all conducted home visits. "This is by far the best way of increasing the uptake of radon mitigation. Visits by technical staff from local authorities or national agencies to offer independent and impartial advice, guidance and reassurance to householders with elevated radon levels, is labor intensive, but highly effective in increasing mitigation."
- Where dedicated telephone hotlines or general advice lines are provided, the general consensus is that they work best where there is a human being on the end of the phone. For a householder sitting at home, it can be very reassuring to be able to speak to someone if they've just received a letter telling them that their house has an elevated level of radon, A staffed phone line also allows callers to ask the questions that concern them and provides useful feedback to program managers on shortfalls in advice and guidance.

Part IV. Strategies for Promoting Mitigation During Real Estate Transactions

Radon testing and mitigation contractors state that more than 80% of the radon testing and mitigation currently being done is occurring in the context of real estate transactions. (Wall, D. & Hill, D., 2005) The Boulder County study demonstrated the potential for reducing exposure to high radon levels by promoting testing and mitigation in the context of real

estate transactions. The European Commission states that "if we are to significantly increase the uptake of radon mitigation measures, it is important that radon is considered at the time of property purchase." (Scivyer, 2003)

In Switzerland, in cases where a house in a radon-affected area has not been tested, a financial retention is made until the radon level has been measured. In the UK, while not a requirement, radon is now one of the issues covered by standard research done voluntarily by most homebuyers when making a purchase decision. The standard questions help to establish whether the property is located within a radon-affected area, whether the property has been tested, if it has been tested, whether it was high or low and if tested high whether the problem has been mitigated. Feedback has shown that there has been significantly more interest in radon since the questions became part of the standard research process. There is also evidence that it is leading to an increase in the performance of radon testing and mitigation. (Scivyer, 2003)

In Boulder County, 36% of the 22 non-IBM homes with radon concentrations above 4 pCi/l were confirmed mitigated before closing. Among a subset of 15 non-IBM homes that tested above 4 pCi/l whose buyers employed a realtor who gave them radon information, 40% were confirmed mitigated. Among the remaining 7 non-IBM home with radon levels above 4 pCi/l whose buyers did not receive radon information from a realtor, 29% were confirmed mitigated. Even when homebuyers did not receive radon information from a realtor, mitigation rates in the context of real estate transactions in Boulder County were higher than typical rates observed during periods in which individuals are neither buying nor selling a home. However, mitigation rates were helped even more by personal contact with a realtor who provided their clients with information about radon, and who may have been taking some of the responsibility for making decisions about radon off the shoulders of the buyer. (Doyle, 1990, p85)

The authors of the Boulder County study suggest that the best way to increase radon mitigation would be to develop a regulatory strategy aimed at the home sale transaction. This strategy would require disclosure of radon level at the time of home sale. "The home sale transaction regulatory strategy exploits a key event – the decision to purchase a home – to focus the attention of the home sale participants (e.g. buyer, seller, mortgage banker, realtor) on the potential health effects of radon contamination. During the home sales transaction, buyers and sellers are focused on the condition of the home. Buyers are anxious to learn as much as possible about the property. Sellers are likely to commit resources to correct any perceived defects." The home sales regulatory strategy makes information about radon levels available in a timely fashion so that protective behavior is framed as part of a high profile, single decision that covers a long time span. It also uses existing channels of social communication by involving mortgage bankers and realtors in disseminating radon information. "And, since the buyer, realtor, and mortgage banker have a strong interest in learning about radon, the strategy is to a large extent self policing." (Doyle, et. al., 1990, p130 – 132)

Conclusions – Strategies for Promoting Mitigation

The limited evidence presented here suggests that capitalizing on the motivational value of real estate transactions may be the most effective way to increase mitigation rates.

Providing people who have high home radon levels with technical and/or financial assistance may also be an important approach. Mitigation rates among participants of New York State's Radon Diagnostic Assistance Program were substantially higher than among residents who didn't participate in the

program. European Union program managers assert that it is the availability of local advice, guidance and technical assistance that encourages people to follow through with mitigation. Mitigation rates in the context of real estate transactions increased when realtors provided clients with radon information and perhaps took some of the responsibility for making decisions about radon. In addition, the 7.9% credible mitigation rate in Washington D.C. suggests that a media campaign alone is unlikely to be sufficient to promote high levels of mitigation. Risk communication experts stress that information alone rarely leads to behavior change, and that it is important to provide easy solutions that individuals feel they can handle themselves. To the extent that easy radon mitigation solutions are not available, it would stand to reason that providing technical and/or financial assistance to carry out more complex ones would increase mitigation rates.

The material presented in this document does leave some unanswered questions about how effective technical and/or financial assistance might be in increasing mitigation rates among a large cross-section of the population. It may be that the people who sought out this type of assistance in New York State would have been more likely to mitigate even if the assistance were not available. New Jersey's evaluation of methods for delivering radon test results indicated that taking the time to have a phone conversation with someone who was already quite knowledgeable about radon did not increase mitigation rates. Additional research on the effect of reaching a broader audience with technical and/or financial assistance would help radon program managers verify best practices for promoting radon mitigation.

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Prepared by Aceti Associates
Arlington, MA
www.acetiassociates.com