

Relationship of Perception of Radon as a Health Risk and Willingness to Engage in Radon Testing and Mitigation

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Purpose/Objectives: To gather data on radon levels and determine correlations among subjects' characteristics, willingness to test for radon, and perceptions of radon as a health risk.

Design: Descriptive correlational.

Setting: Rural DeKalb County in northern Illinois.

Sample: 473 respondents from a group of 1,620 randomly selected county residences.

Methods: Participants were surveyed via telephone using the Community Radon Program questionnaire. Radon measurements were taken with home radon test kits.

Main Research Variables: Gender, income, age, educational level, smoking status, race, home ownership, willingness to test for radon, and radon risk perception.

Findings: Most participants were familiar with radon but did not view it as an immediate health hazard and would not have screened for radon on their own. 88% of the radon measurements exceeded the U.S. Environmental Protection Agency's moderate risk potential level, and 53% exceeded the action level (i.e., 4 pCi/L).

Conclusions: Perception of radon as a health risk was correlated positively with planning to conduct further radon testing and to employ radon mitigation methods. More research is needed on people's willingness to obtain radon emission levels and the cancer rates in areas that have high potential for radon.

Implications for Nursing: According to the environmental literature, the effect of household radon emissions on the development of lung cancer is as great a health risk as second-hand smoke. Virtually no nursing literature on the subject has been published. As the primary source of health information in many rural counties, nurses, especially public health nurses, are at the forefront in public health educational efforts. Nurses are the most likely healthcare professionals to enter patients' homes and can play a significant role in disseminating information about radon as a potential carcinogen.

Radon, a colorless, odorless, radioactive gas, is produced as a result of the decay of uranium and radium, radioactive elements that are found in various concentrations throughout the Earth's crust. Radon can enter and accumulate in homes as a result of the differential pressure between homes and the ground under them, reaching potentially hazardous levels. According to the U.S. Environmental Protection Agency (EPA) (1992b), exposure to indoor radon gas poses a significant risk of lung cancer and causes an estimated

Key Points . . .

- ▶ Radon is classified by the U.S. Environmental Protection Agency and the World Health Organization as a Class A carcinogen.
- ▶ Although residents in this study were aware of the high levels of radon in their county, they did not perceive it as an immediate health risk in their own homes and neighborhoods.
- ▶ In rural areas, nurses often are the primary healthcare providers and the most trusted resources for public outreach programs. Therefore, they should educate residents about radon's health risks.

7,000–30,000 deaths in the United States each year. The Harvard Center for Risk Analysis ranked the inhalation of radon gas as the most important potentially fatal hazard in the home, estimating the annual cause-specific mortality rate to be 5.8 per 100,000 people (DeAscentis & Graham, 1998).

Concerns about the risk of lung cancer from repeated exposure to radon arise from the fact that radon decay produces polonium-218 and -214 isotopes that attach readily to airborne dust. When inhaled, the radioactive particles can lodge in the bronchioles, where they continually emit ionizing radiation to

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surrounding epithelial tissues. The National Research Council's (1998) sixth committee on Biological Effects of Ionizing Radiation (BEIR VI) wrote a report and developed two preferred risk models for the likelihood of radon-induced cancer deaths in the United States. Using the committee's constant relative risk model, the report suggested that the number of radon-induced cancer deaths in the United States could range from 3,000–32,000 annually, making indoor radon the second leading cause of lung cancer after cigarette smoking. The EPA (1992b, 2000), World Health Organization (2000), and U.S. Department of Health and Human Services (2000) have classified radon as a human carcinogen.

Significance to Nursing

The BEIR VI report clearly confirmed radon's role as a class A carcinogen. Major health organizations, both governmental and nongovernmental, have reached the conclusion that radon is second only to cigarette smoking as a cause of lung cancer. Yet little has been written about the topic in the nursing literature, particularly oncology nursing literature. A literature review by Frank-Stromborg and Rohan (1992) found that oncology nursing, as a nursing specialty, has concentrated mostly on a limited number of anatomic sites (i.e., breast and prostate). Almost a decade after that review, a second review (Rohan & Frank-Stromborg, 2002) found that still to be true. Radon-induced lung cancer falls into the area of neglected cancer research. The reviews documented a serious void in oncology nursing research into the prevention of this deadly disease.

Literature Review

Radon Risk

The development of airtight, highly insulated structures has promoted conditions that favor the buildup of radon. Newer homes, especially those constructed since the 1980s, have higher levels of insulation and are constructed more tightly than those built earlier. In addition, many homeowners use central air conditioning and heating systems that encourage the closing of windows and doors to conserve energy, therefore reducing indoor air turnover and ventilation. Unfortunately, the lower levels of many of these dwellings have cracks in foundations; sump pits; gaps in suspended floors, around service pipes, and inside walls; and crawl spaces that permit radon entry and accumulation. Additionally, many homes do not have ventilation systems that expel air from their basements to the outdoors. Consequently, forced air heating causes radon to rise, exposing occupants on upper floors as well.

Radon in Illinois

A 1992 nationwide survey conducted by EPA (1992b) found elevated levels of radon in homes throughout Illinois. More than half of the state was classified as zone one, the highest priority rating for measuring and implementing controls for indoor radon. Beginning in the mid-1980s, the Illinois Department of Nuclear Safety (IDNS) conducted a limited radon screening of a sample of Illinois homes (IDNS, 1986). IDNS placed short-term radon detectors in 4,127 homes throughout the 102 Illinois counties, ranging from 10 in a rural county to 261 in Cook County, where Chicago is. On

average, 40 homes in each county were tested. The screening was conducted as a joint state and local effort involving educational programs for interested local government personnel. In 1992, the screening results showed that 39% of the tested homes had radon levels exceeding the EPA action level of 4 pCi/L (IDNS, 1992).

A limited study conducted jointly by Illinois and EPA from 1990–1992 also found elevated radon levels (IDNS, 1992). Eighteen of the state's 102 counties had measured radon levels higher than 4 pCi/L in more than 50% of the homes tested. The levels of radon varied by local geology and home construction methods. In DeKalb County (classified as zone one), which is the focus of this study, 56 radon measurements were taken and 82% exceeded 4 pCi/L (IDNS).

Although EPA classified the counties in Illinois in terms of estimated indoor radon levels based on a small number of actual measurements, no comprehensive, systematic analysis has been undertaken in any Illinois county to confirm the presence of a significant radon problem. Therefore, before this study, the conclusion that radon posed a public health hazard in DeKalb County was presumptive at best. Because radon levels in homes and other buildings depend on several factors, including construction methods, maintenance, and geologic conditions, only comprehensive sampling can determine the extent and magnitude of the problem.

Previous Research

A review of previous research on radon and its health effects revealed virtually no nursing literature on the topic. A search of the Cumulative Index to Nursing and Allied Health Literature® database for literature written since 1960 produced only two full-length research articles dealing specifically with radon in nursing journals, one published in the United States (Platt, 1993) and the other in the United Kingdom (Laurent, 1996). Two very short discussions about radon (Jones, 1997; Thomas, 1996) also were found; again, only one of the two was in a U.S. journal. The only other related nursing articles dealt indirectly with radon in discussions of "sick building syndrome" or as one of several causes of lung cancer. Similar searches in the Health Academic, Medline®, World Catalog, and General Science Abstracts databases yielded no significant nursing literature on radon. Only one article was found that addressed the issue of indoor air quality in the context of home health care by nurses (Rice, 1999); it dealt with radon as one of a number of indoor health threats. Outside of nursing, a number of relevant studies concerning radon have been conducted and can be grouped into two broad but not necessarily exclusive categories: public perceptions of radon as a health hazard and willingness to address elevated levels of indoor radon.

Several studies have focused on public perceptions of radon as a health hazard. This line of research generally seeks to identify correlates of risk perception, such as gender, income, educational level, and knowledge of radon. The results generally show positive correlations between educational levels and accurate understanding of health risks from radon. As expected, healthcare professionals tended to have a more accurate understanding of radon than the general population. A study of female physicians, however, showed that knowledge of radon as a health risk did not necessarily result in higher radon testing rates (Baldwin, Frank, & Fielding, 1998). Of 4,501 women surveyed, 82% had not conducted radon screening in their homes, although the rate of testing still was two to six times higher than

in the general public. The variable that appeared to be most strongly linked to radon knowledge, information seeking, and willingness to test for radon was perception of personal risk. Various studies have shown that subjects who perceived high personal risk from radon tended to exhibit the highest levels of information-seeking behavior, were the most knowledgeable regarding radon's potential health effects (Kennedy, Probart, & Dorman, 1991; Weinstein, Sandman, & Roberts, 1991), and were most likely to retest their homes for radon when elevated levels were detected (Halpern & Warner, 1994).

Using data from the 1990 National Health Interview Survey, Halpern and Warner (1994) conducted a statistical analysis of the findings to explore the links between demographic characteristics of respondents and radon knowledge, perception of radon as a health hazard, and mitigation behavior. They found that fewer than one-third of 28,000 respondents correctly identified lung cancer as a health effect of radon, and a similar number identified other cancers (a true effect) and headaches (a false effect) as being caused by radon. The study suggested that although people might have a general comprehension of radon's carcinogenic effects, equally incorrect perceptions about its health effects might exist. Halpern and Warner also found a significant relationship between having accurate radon information and being willing to employ radon mitigation techniques when the perception of personal risk was high because of elevated radon measurements in the home.

The second category of research on radon focuses on the willingness of residents and building owners to address elevated levels of indoor radon. The New York State Department of Health, for example, conducted a survey from September 1995–January 1996 to discover whether perceptions of health risks from radon among residents whose homes previously had been found to have high radon levels affected their decision to implement radon mitigation techniques (Wang, Ju, Stark, & Teresi, 1999). Findings demonstrated that the cost of mitigation systems was a major factor in deciding whether to take action. Despite the expense, 60% of those surveyed in the New York study performed some type of radon reduction, citing radon's health risks as a major motivating factor. This surprised researchers because professionally installed mitigation techniques average \$1,200 and range from \$500–\$2,000 (EPA, 1993). However, Wang et al. concluded that increasing awareness of radon's health risks, along with introducing less expensive methods of reducing radon, may help increase the public's willingness to apply radon mitigation techniques.

Ford and Ehemann (1997) and Evdokimoff and Ozonoff (1992) showed lower levels of follow-up mitigation than the New York study. Ford and Ehemann examined the mitigation actions of participants of the National Health Interview Survey whose homes had high radon levels. They found that few people (28%) employed radon mitigation techniques after receiving high radon measurements. They also found low levels of follow-up radon testing: 34% of homes with high radon levels in 1990 ($n = 7,230$) and 41% of those with high levels in 1991 ($n = 3,468$). However, the Massachusetts Department of Environmental Health, in its 1992 survey (Evdokimoff & Ozonoff), found a positive relationship between follow-up radon testing and mitigation and high levels of radon determined at initial radon screening. In general, the higher the measured radon level, the more likely residents were to conduct follow-up tests and initiate reduction procedures. The

overall incidence of retesting and mitigation, however, was relatively low, as it was in the Ford and Ehemann study.

Background and Purpose

This research project was part of a series of cancer prevention and education programs for DeKalb County sponsored by the School of Nursing at Northern Illinois University and Kishwaukee Community Hospital, both in DeKalb, IL. The purpose of the study was threefold: to determine the range of radon levels in DeKalb County homes, explore demographic and other correlates of the public's perceptions of radon as a health hazard, and determine the public's willingness to test for radon and employ radon reduction techniques when recommended levels were exceeded. Previous surveys of radon levels in Illinois, particularly in DeKalb County, have been neither comprehensive nor representative because of the small sampling fractions. In addition, radon continues to be underestimated as a potential public health hazard; most residents have not tested for radon despite the availability of simple, inexpensive, self-administered test kits (Glass, Mensah, & Croke, 1992). This is especially noteworthy in DeKalb County, where high levels of radium, a precursor of radon, have been detected in the water supplies of several communities.

Radon test kits and mitigation techniques range in price and complexity of use. Do-it-yourself test kits can be simple to use, and one type of four-day test kit costs about \$9. Professionally installed radon mitigation systems range from \$500–\$2,000 (EPA, 1993). However, consumers can implement many mitigation systems themselves. One simple technique is to spray a concrete sealer formulated to penetrate concrete and block radon. It costs about \$200–\$400 for the average single-family home. Another system involves installing ventilation pipes connected to cooling and heating systems to the outside of homes. When the air conditioner is used, it draws exterior air indoors through the pipes for cooling, which also serves to ventilate the home and expel accumulated indoor radon gas.

This study built on previous research and examined the public's knowledge of radon, as well as associations between personal characteristics and perceptions of radon as a health risk, willingness to test for radon, and readiness to use radon mitigation procedures when radon levels exceed EPA's maximum.

Theoretical Framework

The Risk Perception Model was selected as the theoretical model for this study because it was the most applicable theory dealing with public responses to environmental health issues. The model was applicable because it was used in previous research on public decision making regarding health hazards from radon (Weinstein, Klotz, & Sandman, 1988; Weinstein, Sandman, & Roberts, 1990; Weinstein & Sandman, 1992).

The Risk Perception Model asserts that public response to environmental issues is governed by perceptions of risk that are mediated by "outrage factors." These outrage factors, which are qualitative in nature, include perceived degree of individual control, severity of the hazard, and nature and source of the hazard. Hazard is the quantitative measure of risk, such as excess morbidity or mortality in a stated time period (Oleckno, 1995). In describing the model, Sandman (1987) defined risk as the combined outcome of hazard plus

outrage. Sandman argued that experts often fail to communicate environmental risks because they focus on hazard when attempting to convey the significance of a particular health risk, but the public focuses on outrage factors. A goal of risk communication is to develop a methodology for officials to provide accurate health information to the public in a manner that they can understand and evaluate. Effective risk communication is vital to reaching a consensus in managing health risks; it may involve reducing public fears when outrage is high compared to hazard or raising the level of public concern when outrage is low compared to hazard, as is the case with radon (Oleckno).

Methods

Research Questions and Hypothesis

This study examined three research questions.

- What is the range of residential radon levels in DeKalb County?
- What is the understanding of DeKalb County residents regarding radon as a health hazard?
- What factors are associated with DeKalb County residents' perceptions of risk from radon exposure, willingness to test for radon, and readiness to employ radon mitigation measures when appropriate?

In addition to examining a number of possible correlates of respondents' knowledge and perceptions of the risks of radon exposure, the researchers hypothesized that perception of radon as a serious health threat was an independent predictor of intentions to test for radon and implement radon mitigation procedures. Other independent variables that were tested for their effects on radon risk perception, radon testing, and mitigation behavior included gender, income, age, educational level, smoking status, race, and home ownership.

Sampling Procedure

To determine how many homes had to participate to ensure a representative sampling of DeKalb County, which had 27,351 single-family homes (U.S. Census Bureau, 1990), the researchers used a general sample size formula with a precision level of 0.05 and a confidence level of 0.95. The result indicated that a sample size of at least 379 homes would be required to statistically represent DeKalb County's population. The targeted sample consisted of 1,620 randomly selected households. To help ensure that the sample reflected the distribution of households inside versus outside town limits, the sample was stratified by location of homes inside or outside town limits. The stratification was designed to maintain the same ratio of in-town and out-of-town residences in each township as reported in the 1990 U.S. Census. For purposes of the study, the term urban was used to refer to towns with at least 2,500 residences. Out-of-town residences were referred to as rural to include all towns with fewer than 2,500 residences.

Procedures

The study involved three stages. During stage one, a letter was sent to the stratified, random sample of 1,620 single-family DeKalb County residences offering free radon testing in exchange for completing a brief telephone survey about radon. The letter explained the purpose of the study and that the geographic area was believed to have high levels of radon. The letter invited the head of each household to participate in

the free radon testing. Those who were interested were asked to return a prepaid postcard indicating their willingness to participate. The postcard asked for a daytime telephone number and the most convenient day and time for the research team to call. Those who returned postcards were contacted by telephone at the times indicated and were asked to respond to 30 questions that averaged five minutes to complete. The participants were assured that their responses would be kept confidential and that they could refuse to answer any question at any time.

In stage two of the study, each telephone survey respondent was mailed two radon test kits, radon testing instructions, and additional IDNS radon information. The radon test kits were supplied by Air Chek, Inc., and consisted of charcoal test kits meeting EPA (1993) guidelines for short-term measurements under closed conditions. Respondents were informed at the end of the initial telephone survey (i.e., stage one) that closed conditions should be maintained for the duration of testing. This also was presented in the test instructions mailed with the test kits during stage two. After radon testing was completed, participants were asked to return the kits to the research program. Testing information provided by the respondents, such as test location, duration, and room temperature, was recorded. Within seven days from the ending date of measurement, the kits were mailed to the Air Chek laboratories, which sent results back to the research program.

In stage three, results were mailed to the appropriate participants, along with radon mitigation brochures produced by EPA and provided by IDNS. Subjects whose homes tested higher than EPA's recommended action level of 4 pCi/L received information about how to reduce radon levels. In addition, a follow-up questionnaire with five final survey questions on a prepaid return postcard was enclosed.

Study Instruments

Questions used in the stage one survey were based on the 1990 National Health Interview Survey questions used by Halpern and Warner (1994) in their study of demographic correlates of radon knowledge, as well as the instrument developed by Ferng and Lawson (1996) for their study of residents in geographic areas with high levels of radon. Stage one was pilot tested with 20 participants of varying ages, educational levels, and socioeconomic statuses to identify misleading or confusing questions. The pilot test revealed an average completion time of five minutes by telephone and that the questions were clear and understandable. Thirty percent ($n = 6$) of the pilot participants preferred not to answer the item pertaining to income. As a result, an option of "refuse to respond" was added to each question.

The final version of the telephone survey included questions about variables related to radon knowledge, perception of personal risk from radon exposure, willingness to test for radon, and willingness to employ radon mitigation methods, in addition to personal characteristics (e.g., age, sex, race, education, income, smoking status), all of which were pilot tested. The questions about risk perception asked respondents to rate the seriousness of radon and cigarette smoking as health hazards on a scale of 1–5, with 5 being the highest. The follow-up questionnaire in stage three was printed on a prepaid return postcard and mailed with radon test results. It included five items relating to perception of radon as a health hazard, plans for follow-up radon testing, and plans to reduce radon levels.

Data Analysis

The results of the radon tests and the responses to the stage one and three surveys were analyzed using univariate and multivariate techniques. Univariate statistics were used to address the three research questions, including the range of residential radon levels in DeKalb County, residents' understanding of the health hazards of radon, and residents' perceptions of risk from radon exposure, willingness to test for radon, and readiness to employ radon mitigation measures when appropriate. Multiple logistic regression using the likelihood ratio procedure was used to test the research hypothesis that personal perception of radon as a serious health threat was an independent predictor of intentions to test for radon and implement radon mitigation procedures. All data analyses were conducted using version 10.0.5 of SPSS® (SPSS Inc., Chicago, IL) for Windows® (Microsoft Corp., Redmond, WA).

Results

Sample

Publicity regarding the study resulted in many individuals contacting the research program to request that they be included. Because the project was funded by a trust fund administered through the local hospital, whose primary goal is public service, a decision was made to include all DeKalb County households requesting participation in the study even if they had not been selected randomly. Therefore, the final sample from the telephone survey (N = 473) included 135 self-selected residences (29% of the total respondents). The survey responses from the self-selected group were tested and compared to those from the randomly selected participants. The inclusion or exclusion of the self-selected group did not produce any significant differences in the study's results. Therefore, selection bias caused by inclusion of self-selected participants was unlikely. The final sample of households represented 29% of the number originally targeted for analysis and was 66% urban and 34% rural, reflecting a moderate urban bias based on the 1990 U.S. Census for DeKalb County. Whether the difference was the result of the inclusion of the self-selected participants, sampling error resulting from the overall low response rate, or changes in the distribution of households since the census was unclear. Of the 473 total respondents to stage one, 63% (n = 298) responded to stage three after receipt of radon test results.

Table 1 summarizes the characteristics of the households sampled in stage one. Overall, 90% of the residences were single-family households, 92% were owned by the occupants, and 67% were built before 1980. In 98% of cases, the master bedrooms were above ground. Forty-nine percent of respondents reported annual household incomes from \$50,000–\$99,999. Women made up 77% of the respondents. Seventy-three percent of respondents were 40 or older, with the mean age falling in the 40–54 age group and the age range being 18–65 or older. Ninety-seven percent classified themselves as white/Caucasian. Eighty-two percent had completed at least some college, and 46% held bachelor's or higher degrees. About 10% of the respondents were licensed healthcare practitioners.

Radon Levels in DeKalb County

In this study, 53% of all measurements taken were higher than the EPA action level of 4 pCi/L and 88% exceeded EPA's goal of 2.0 pCi/L for indoor radon following mitigation. As

expected, 44% of the action level results were obtained from basements. Of interest, however, was the high number of upper floors that also yielded high radon measurements because that is where residents spend most of their time. Of nonbasement floors, 46% were above the national average for indoor radon and 11% were above the action level. In addition, 25% of measurements taken where residents declined to reveal testing locations were above the action level. Spatial analysis of the radon measurements using a spot map indicated that the range of radon measurements did not vary across the county. Low, medium, and high radon levels were equally distributed in both rural and urban areas throughout the county. Table 2 summarizes the distribution of radon levels detected in the sample and their potential health effects based on EPA (1992a) estimates.

Knowledge of Radon as a Health Hazard

About 96% of the respondents had heard of radon prior to the study, and 88% correctly identified radon as a gas. More than half of the respondents (56%) knew that radon is associated with lung cancer, although only 44% identified it as a possible cause of other cancers. Knowledge of radon as a gas was associated with knowledge of radon as a cause of lung cancer ($\chi^2 = 43.2[1]$, $p < 0.001$). About 30% of the respondents identified radon as a cause of headaches, and 16% identified it as a cause of asthma. Overall, 32% were not sure what health effects are associated with radon. The majority of respondents (76%) were

Table 1. Summary of Characteristics of the Sample Households

Variable	n	%
Type of residence		
Single family	427	90
Duplex, condominium, townhouse	23	5
Apartment	18	4
Other	5	1
Ownership status		
Own residence	431	92
Rent, lease, etc.	40	9
Year built		
Before 1960	166	35
1960–1979	153	32
1980–1989	34	7
1990–2000	101	21
Not sure	19	4
Location of master bedroom		
Below ground level	10	2
First floor	270	57
Second floor	187	40
Above second floor	5	1
Household income		
Less than \$25,000	39	10
\$25,000–\$49,999	120	29
\$50,000–\$99,999	201	49
\$100,000 or more	37	9
Not sure	13	3

N = 473

Note. Because of rounding and because respondents were given the option to not answer any question, n values may not total 473 and percentages may not total 100.

Table 2. Measured Radon Levels in DeKalb County and Potential Health Effects

Radon Level	% of Homes With Measurable Radon	EPA Radon-Induced Lung Cancer Estimates for Nonsmokers
20 pCi/L	2	3 people per 1,000
10 pCi/L	5	4 people per 1,000
8 pCi/L	4	3 people per 1,000
4 pCi/L	17	2 people per 1,000
2 pCi/L	23	1 person per 1,000
1.3 pCi/L	20	< 1 person per 1,000
0.4 pCi/L	17	< 1 person per 1,000

N = 794 measurements

EPA—U.S. Environmental Protection Agency

not sure whether radon was a hazard in their neighborhoods. When asked about their perceptions of radon as a health hazard, 55% rated radon exposure as a serious health hazard (4 or 5 on a scale of 1–5, with 5 being the most serious). By contrast, 93% rated cigarette smoking as a serious health hazard. Table 3 summarizes risk perceptions and the responses to radon knowledge questions.

Correlates of Risk Perception, Testing, and Mitigation

A significant association was found between perceiving radon as a serious health hazard before receiving radon measurement results and planning to test for radon ($\chi^2 = 7.4[2]$, $p = 0.025$). This association also existed among those who responded after receipt of radon test results ($\chi^2 = 9.0[2]$, $p = 0.011$). Among this latter group, a significant association also was found between planning a follow-up test for radon and planning to reduce radon in the home ($\chi^2 = 117.5[1]$, $p = 0.001$). No significant relationship was found, however, between respondents' perception of radon as a health hazard and their stated plans to reduce radon as expressed in their responses to questions on the stage three survey ($\chi^2 = 5.0[2]$, $p = 0.085$).

Multivariate analyses were conducted using three separate logistic regression analyses to identify potential predictor variables. All three analyses employed a backward stepwise elimination procedure using the likelihood ratio test. In the first analysis, 10 predictor variables (i.e., age, gender, race, income, education, healthcare practitioner status, smoking habits, home ownership, knowledge of radon, and perception of the hazards of smoking) were entered into the initial model to determine their association with the respondents' perceptions of radon as a health hazard. The final reduced model was able to predict 67% of the responses. In addition to the constant ($p < 0.001$) two predictor variables in the reduced model, age and gender were related significantly to the perception of radon as a health hazard. In general, the odds of perceiving radon as a serious health hazard were related positively to gender (odds ratio [OR] = 1.49, 95% confidence interval [CI] = 1.16–1.92) and related inversely to age group (OR = 0.79, CI = 0.64–0.98). Specifically, the odds of women perceiving radon as a serious health hazard were almost 50% higher than those of men doing so. In terms of age, older groups were less likely to perceive radon as a serious risk than younger groups.

Table 3. Radon Knowledge and Risk Perceptions

Variable	n	%
Awareness of radon	473	
Heard of radon in the past		96
Did not hear of radon		3
Not sure		1
Perception of radon as a problem	473	
Radon is a problem in my neighborhood.		9
Radon is not a problem in my neighborhood.		15
Not sure		76
Knowledge of radon	456	
Radon is a gas.		88
Radon is a liquid or solid.		1
Not sure		11
Hazard perception: Cigarette smoking as a health hazard	472	
Minor hazard		2
Moderate hazard		2
Serious hazard		93
Not sure		0
Hazard perception: Radon as a health hazard	453	
Minor hazard		7
Moderate hazard		17
Serious hazard		55
Not sure		21
Hazard perception: Radon as a health hazard after radon testing	296	
Minor hazard		11
Moderate hazard		16
Serious hazard		55
Not sure		17
Knowledge of health effects associated with radon^a	471	
Lung cancer		56
Headache		30
Arthritis		7
Asthma		16
Other cancers		44
Not sure		32

Note. Because of rounding and because respondents were given the option to not answer any question, n values may not total 473 and percentages may not total 100.

^a Responses were not mutually exclusive.

For each approximate 10-year increase in age, the odds of indicating that radon is a serious health hazard decreased by 21%.

The second analysis examined factors related to planning to conduct a follow-up test for radon after receipt of radon test results. Five predictor variables (i.e., radon test result, perception of radon as a health hazard, age, gender, and race) were entered into the initial model. The age ranges were collapsed into six groups: 18–24 (n = 140), 25–29 (n = 26), 30–39 (n = 87), 40–54 (n = 161), 55–64 (n = 79), and older than 65 (n =

102). The final reduced model correctly predicted 73% of the responses about plans to conduct follow-up testing. This model suggested that the odds of planning a follow-up test for radon were about six times higher among those who received radon test results that were above the EPA action level of 4 pCi/L, compared to the average odds across all test result categories after adjusting for perception of radon as a health hazard, age, gender, and race (OR = 5.57, 95% CI = 2.77–11.19). In addition, perception of radon as a serious health hazard after receipt of radon test results was a significant predictor of planning a follow-up test for radon after controlling for test results, age, gender, and race (OR = 2.30, 95% CI = 1.19–4.47).

Variables used in the second analysis (i.e., radon test result, perception of radon as a health hazard, age, gender, and race) also were entered as predictors of respondents' plans to reduce radon after receipt of radon test results. The reduced model in this case was able to identify 76% of the responses correctly. As in the previous analysis, receipt of radon test results showing levels higher than 4 pCi/L was a significant predictor of planning to reduce radon after adjusting for age, gender, race, and perception of radon as a health hazard (OR = 3.42, 95% CI = 1.77–6.60). Compared to the average odds of reducing radon based on test results, the odds of reducing radon for those with results higher than 4 pCi/L was 142% higher. In addition, age was associated inversely with planning to reduce radon after receipt of radon test results (OR = 0.73, 95% CI = 0.53–0.99). In general, older participants were less likely to plan to reduce radon levels than the younger respondents after controlling for radon test results, perception of radon as a health hazard, gender, and race.

Discussion

This study found that radon is a potentially serious problem in DeKalb County. Researchers discovered that 186 (46%) homes had measured radon levels higher than EPA's action level of 4 pCi/L, confirming earlier reports of elevated levels in the county (IDNS, 1992) and EPA's rating of DeKalb County as a high-risk area for radon. Of the 186 homes with measured radon levels higher than 4 pCi/L, 57 had levels exceeding 4pCi/L in both the basement and an upper floor. In fact, 44% of basements and 11% of first and second floors tested exceeded the action level. In addition, 25% of the 44 measurements whose locations were not disclosed by residents were above the EPA action level. Also, 88% of all test results showed levels exceeding EPA's goal of 2.0 pCi/L for indoor radon levels after mitigation.

The study found that although DeKalb County residents generally were aware of radon, they seemed to be less certain about its specific health effects. This is consistent with the findings of Halpern and Warner (1994), who found that similar percentages of respondents identified radon as a cause of lung cancer and a cause of headaches.

A significant number of respondents in this study appeared to underestimate the seriousness of long-term radon exposure compared to the beliefs of leading authorities on the issue, such as EPA and the World Health Organization. This perception of radon as being less hazardous than hypothesized is consistent with the Risk Perception Model posited by Sandman (1987). One explanation for this perception could be that because radon is a natural product and its effects are not generally observable, little outrage is generated. This also may be the reason that so

few have tested their homes for radon in DeKalb County. In this study, almost 80% of respondents indicated that they had not tested for radon and about 10% were unsure if testing had been conducted. Furthermore, more than half of the respondents receiving test results said they did not plan to retest for radon or reduce radon levels in their homes. These findings are consistent with those of Field, Kross, and Vust (1993); Ford and Ehemann (1997); and Weinstein et al. (1991).

In general, the findings of this study showed that women tended to view radon exposure as a greater health hazard than men did, and older people tended to view radon exposure as less of a health hazard than younger people did. These findings are consistent with those of Ferng and Lawson (1996), Halpern and Warner (1994), and Mainous and Hagen (1993). This finding may have implications for community-education programs about radon.

Planning to conduct follow-up tests for radon after receipt of radon test results was related to the level of radon detected and the subsequent perception of radon as a health hazard after controlling for age, gender, and race. These findings were consistent with those of Evdokimoff and Ozonoff (1992); Field et al. (1993); Ford, Ehemann, Siegel, and Garbe (1996); Kennedy et al. (1991); Wang et al. (1999); and Weinstein et al. (1991). Planning to reduce radon, however, was related to radon test results and age but not to the perception of radon as a health hazard in the model examined in the second analysis. Thus, only partial support existed for the research hypothesis that perception of radon as a serious health hazard was an independent predictor of intentions to test for radon and implement reduction strategies. Previous findings of a relationship between planning to reduce radon and perception of radon as a health hazard in other studies generally have been weak to moderate; therefore, partial confirmation of the hypothesis in this study was not totally unexpected (Field et al.; Weinstein et al., 1991).

When levels of radon detected in DeKalb County homes are considered, a need clearly exists for public outreach programs to educate residents about radon exposure as a public health issue. This study shows that education programs are essential in areas with high levels of radon, such as DeKalb County, which is rated zone one (i.e., greatest need) under EPA's classification system. Residents may have been familiar with the presence of radon, but the depth of understanding of radon's health effects appeared to be limited. Before testing, residents were unsure whether radon was a hazard in their own homes. Special emphasis also should be made to educate residents about radon's carcinogenic effects. Knowledge of high radon levels and perception of radon as a serious health hazard are predictors of intentions to test for radon and implement reduction procedures. Thus, if the public can be made to understand the potentially serious consequences of long-term radon exposure, they likely will take appropriate preventive measures.

Implications for Nursing Practice and Research

The findings of this study have several implications for nursing practice. Community health nurses should determine their communities' EPA radon hazard ratings. Based on the estimated potential for radon hazard in their communities, nurses can establish community-education programs regarding the indoor cancer risk. Health education programs must include information about the serious health effects of chronic radon

exposure, as well as efforts to counter widespread misperception of false health effects, such as headaches and asthma.

After educating communities about radon's health effects, nurses can advocate for radon testing programs to determine actual radon levels in local homes. Education programs should be accompanied by information on actual radon levels in communities, as well as efforts to promote testing and mitigation behavior, because awareness of radon as a theoretical and empirical health hazard and its general presence in the community was shown in this study to be less significant than perception of personal risk from radon in affecting radon testing and mitigation behaviors.

Nurses must play a leading role in educating the public of the possible effects of radon, as well as its presence in their communities. Radon awareness can be a component of nurses' discussions of cancer risks with their patients. While the public may be more familiar with "sick building syndrome," radon is less known and can be incorporated into counseling sessions on cancer risks as one of several indoor environmental health hazards, such as smoking. This is especially important because radon exposure and cigarette smoking have been shown to have a synergistic relationship, multiplying the likelihood of developing lung cancer than either cigarette smoking or radon exposure alone (EPA, 1992b; Saccomano, Huth, Auerbach, & Kuschner, 1988; Samet, 1989).

Just as nurses can set examples for their patients by stopping smoking themselves, they can lead by example and test their own homes for radon. By doing so, nurses could speak from personal experience when informing patients of the relative ease and low cost of radon testing. Additionally, nurses can discuss alternative, less expensive mitigation techniques from firsthand experience. Homeowners can use many techniques, such as installing outside ventilation tubing or sealing cement floors, to save the labor costs of professionally installed systems. Simple methods, such as sealing sump pumps and cracks in basement walls, can be effective in reducing overall indoor radon levels. Home healthcare and oncology nurses are in a unique position to disseminate radon information because of the nature of their contact with the public; they should take advantage of this access to educate their communities about this threat.

Although radon is a relatively new topic for oncology nurses, its carcinogenic potential must be monitored. Its long-term health effects in residential environments are emerging only now. Because homes with "closed" conditions first were constructed in large numbers starting in the 1980s, the long-term effects of indoor radon exposure are starting to emerge now. Exploration of the connection between radon and cancer, as well as research into any recent increase of cancer in high-risk communities, is an important area for future research.

Nurses, especially oncology nurses, can seize the initiative currently lacking in the healthcare literature and become leaders in radon-induced lung cancer research and prevention in several ways. First, the focus of oncology nursing must extend beyond breast and prostate cancers. Indeed, cancers that are related to increased age are growing in incidence as life expectancies continue to rise. As the graying of America continues, cancers that become prevalent with aging will increase. Radon-induced lung cancer is a long-term health hazard, appearing after a decade of exposure (Field et al., 1993). Because prolonged exposure to radon increases the potential to develop lung cancer by 50%, it falls into the field of significant long-term exposure-induced cancers.

Second, nurses can achieve a stronger and more prominent role in primary cancer-prevention research through radon research programs. Radon is a community-based, indoor threat in homes, making nursing the logical discipline to lead the way in environmental radon screening and cancer prevention. Nurses have insight into their particular communities and patient populations and are the healthcare providers most often in direct contact with patients. These patients trust nurses, who can provide information that patients could obtain otherwise only from governmental offices, such as EPA or local municipality water and soil boards. Many people are afraid to contact official resources for information about radon in their homes for fear of attracting regulatory scrutiny of their properties that may result in negative real estate or other property regulations. Nurses can serve as trusted confidential sources of information about radon testing and prevention measures, just as they do on other preventive health issues (Mahon, 1998). In addition, as nurses already do in dealing with translating other medical information into layman terms, they can interpret technical radon testing, prevention, mitigation, and health-effects information for their patients.

Finally, many primary prevention programs tend to take place in traditional hospital settings. Nurses should conduct prevention and early detection programs throughout communities and workplace settings (Howell, Nelson-Martens, Krebs, Kaszyk, & Wold, 1998). Programs such as prostate and breast cancer screenings often are promoted successfully in such nonhealthcare settings. Other prevention programs, such as antismoking and heart disease education, can be similarly successful. Radon testing and mitigation easily can be included in lists of community-based, cancer-prevention programs.

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- ▶ Radon.com
www.radon.com
- ▶ National Environmental Health Association
National Radon Proficiency Program
www.radongas.org

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Call for Nominations

ONS Trish Greene Quality of Life Lectureship Supported by Purdue Pharma LP

Nominations currently are being accepted for the ONS Trish Greene Quality of Life (QOL) Lectureship. The award is in memory of Trish Greene, an oncology nursing leader and pain management expert who was active in ONS. She died of cancer in 1999. The award is supported by Purdue Pharma LP.

Purposes: This lectureship is designed to focus attention on QOL issues in cancer care; describe the contributions of clinicians, educators, administrators, and researchers in oncology nursing to QOL in cancer care; apply information related to QOL to oncology nursing practice; and incorporate the philosophy of QOL into all aspects of cancer care. The lecture is presented at the ONS Annual Institutes of Learning.

Nomination criteria: The nominee must hold licensure as an RN; contribute

to the specialty of oncology nursing; be an ONS member who actively participates in ONS activities; demonstrate excellence in clinical practice, education, administration, or research related to QOL issues; and communicate effectively through written and verbal formats. The award recipient will receive a \$2,000 honorarium, waiver of Institutes of Learning registration fees, and a plaque from Purdue Pharma LP. The award recipient's lecture will be published in the *Clinical Journal of Oncology Nursing*.

Deadline: Nomination forms must arrive in the ONS National Office no later than **December 1, 2002**.

To receive a nomination form, contact Meeting Services at the National Office at 412-859-6216.