FACTORS ASSOCIATED WITH RESIDENTIAL RADON TESTING INTENTIONS AMONG KENTUCKY HOMEOWNERS

Gwendolyn H. Rinker, PhD, ARNP, University of Kentucky, Lexington, KY

Abstract

Kentucky leads the nation in both lung cancer incidence and percent smoking. In addition, many of the counties have average radon levels above the Environmental Protection Agency recommended action level. Guided by the Precaution Adoption Process Model, the purposes of this study were to: 1) examine the relationship between synergistic risk perception (radon plus tobacco smoke) and intention to test for radon; and 2) investigate the association between situational factors, smoking status, and intention to test for radon. A cross-sectional study design was utilized to survey two groups: 1) a convenience sample of those requesting radon test kits through the Kentucky Radon Program; and 2) randomly selected homeowners from five Kentucky counties. Test kit requests from the random group were then tracked. Results from multivariate logistic regression analysis examining factors associated with radon testing intention will be presented. This study will be useful in planning interventions to increase radon testing in Kentucky.

This research was supported by: 1) dissertation research awards from the Clean Indoor Air Partnership, University of Kentucky, and the Delta Psi Chapter of Sigma Theta Tau International Honor Society for Nursing; and 2) a pre-doctoral traineeship from the Rural Cancer Control Program, University of Kentucky, funded by the National Cancer Institute.

The purpose of this study was to examine factors that are associated with radon testing intentions among Kentucky homeowners. Exposure to radon, a naturally occurring gas derived from the decomposition of uranium in the ground, is the second leading cause of lung cancer, and is associated with an estimated 15,400 to 21,800 cases of lung cancer cases in the United States each year (National Research Council, 1999). Lung cancer is the second most commonly diagnosed cancer and has the highest mortality rate of all cancers (National Cancer Institute, 2007). Primary prevention of radon-related lung cancer is accomplished by first testing for radon levels and then installing radon mitigation systems to ventilate radon from homes with high radon levels (Environmental Protection Agency, 2009).

Radon risk reduction is particularly relevant in Kentucky, which has the nation's highest lung cancer incidence rate (101.2 versus 69.1 per 100,000) (National Cancer Institute, 2008); the third highest percentage of adults who smoke (25.2 versus 18.4 percent) (Centers for Disease Control and Prevention, 2008); and counties with radon levels greater than 4 picocuries per liter (pCi/L), the action level designated by the U.S. Environmental Protection Agency (EPA) (Environmental Protection Agency, 2009). According to the EPA, Kentucky has 30 "Zone One" counties, defined as counties with predicted indoor radon levels of 4pCi/L or higher, and most of the remaining counties have predicted levels between 2 and 4 pCi/L (Environmental Protection Agency, n.d.). Further analysis of residential radon values from the Kentucky Radon Program data describes even more counties above the 4 pCi/L level than those reported by the EPA (Kentucky Cabinet for Health and Family Services, 2004), with 46% of residential radon values greater than 4 pCi/L (Clay Hardwick, Kentucky Radon Program, personal communication, February 2, 2009).

Public awareness of radon is generally high, with 52-82% reporting having heard of radon (Environics Research Group, 2007; Gregory & Jalbert, n.d.; Halpern & Warner, 1994; Wang, Ju, Stark, & Teresi, 2000). These same authors report that despite increasing public awareness of radon, only 8-15% have tested or considered testing for radon. The gap between radon awareness and testing presents a challenge to public health professionals attempting to decrease lung cancer risk. This study addresses that gap by focusing on the factors that influence the progression through the process of the adoption of intention to test for radon (see Figure 1), as described in the Precaution Adoption Process Model (PAPM).

Previous studies have examined the correlates of radon testing intentions and behaviors utilizing the PAPM. Factors positively correlated with deciding to test include: perceived risk likelihood, knowing others who had tested (Sandman & Weinstein, 1993; Weinstein & Sandman, 1992a), and perceived susceptibility (Sandman & Weinstein, 1993). Perceived effectiveness of mitigation (Weinstein, Sandman, & Roberts, 1991) and perceived difficulty of radon mitigation have not been shown to impact the decision to test for radon (Weinstein, Sandman, & Roberts, 1990; Weinstein et al., 1991). Correlates of intentions to test for radon include: perceived community radon risk, perceived personal susceptibility, perceived severity, perceived community concern, number of known radon testers known by an individual (Weinstein et al., 1991). Correlates of test kit orders include: perceived personal susceptibility, perceived severity of illness from radon, and intention to test for radon (Weinstein et al., 1991).

Other factors that have been positively associated with radon testing include: education (Wang et al., 2000), income (Halpern & Warner, 1994; Hill, Butterfield, & Larsson, 2006), female gender (Halpern & Warner, 1994), the presence of children living in the home (DiPofi,

LaTour, & Henthorne, 2001), home ownership (Hill et al., 2006), and younger age (Halpern & Warner, 1994; Wang et al., 2000).

Synergistic Risk Perception

Synergistic risk perception, one's assessment of risk from the combination of radon and smoking, was also measured in this study. The rationale for the inclusion of synergistic risk perception measurement is two-fold. First, the risk factors of radon and tobacco smoking are related, with more radon-related lung cancers occurring in individuals with a history of smoking (National Research Council, 1999). Although radon is a risk for both smokers and nonsmokers, those who have smoked and have had radon exposure are at a higher risk of developing lung cancer because of the multiplicative or synergistic interaction between tobacco smoke and radon on lung cancer risk.

Second, there is evidence that perception of the synergistic risk between tobacco smoke and radon may predict changes in smoking behaviors and influence radon risk reduction behaviors. One group studied the impact of a radon and smoking educational intervention, synergistic risk perception and personality characteristics on smoking behaviors among smoking households who had requested radon test kits and found that those with who were more conscientious and who had higher synergistic risk perception were more likely to reduce indoor smoking (Hampson, Andrews, Barckley, Lichtenstein, & Lee, 2000). An extension and partial replication of this study demonstrated that households with radon levels ≥ 4 pCi/L were more likely to institute a new household smoking ban at the 12 months follow-up than households with radon levels < 4 pCi/L (Lichtenstein et al., 2008). Both a video and telephone counseling for smokers about the combined risk of radon and smoking was positively associated with requests for radon information, and those in the telephone counseling intervention group who had high

screening radon values were more likely to perform repeat radon tests and attempt to mitigate their homes (Lichtenstein et al., 2008). There is a need for further study regarding the influence of synergistic risk perception on radon risk reduction behaviors. If synergistic risk perception were found to predict both radon and tobacco related risk reductions, interventions which increase the perception of these combined risks could have significant import for lung cancer prevention.

The purposes of this study were to: a) determine differences in demographics and reasons for not testing between those who intend to test and those who do not; b) investigate whether perceived susceptibility, synergistic risk perception, synergistic knowledge, perceived severity, social influence, and smoking status influence intention to test for radon, controlling for age, gender and education; and c) assess the relationship between the stage of the Precaution Adoption Model for testing and the order of new test kits by those in a random sample of homeowners in selected Kentucky counties. The Precaution Adoption Process Model (PAPM), a stage-based model that identifies phases along the route to protective health action, guided the study aims and hypotheses, and is further described in Figure 1.

Hypothesis 1: Female gender, younger age, and higher socioeconomic status will be related to radon testing intentions.

Hypothesis 2: Perceived severity, perceived susceptibility, synergistic risk perception, synergistic knowledge, social influence, and smoking status will be associated with radon testing intentions.

Hypothesis 3: The proportion of those in the random sample who request a free test kit will be higher among those in PAPM stages 5 or 6 than in stages 1 through 4.

Methods

Design

The study had two phases: 1) a cross-sectional, non-experimental design in which data were collected via mailed survey from two subsamples of Kentucky, and 2) a prospective design in which survey participants in the random sample were invited to request a free radon test kit (see Figure 2).

Sample

Sampling for this study was done in two stages and included two subgroups (see Figure 2). The first subgroup was comprised of a stratified random sample of 40 property owners from each of five Kentucky counties ($N = 200$). The accessible population of five Kentucky counties was selected using the following criteria to ensure variability: 1) counties with differences in the amount of radon testing done in the past; 2) rural and urban counties; 3) counties from different regions of the state; and 4) counties with diversity in lung cancer incidence, percent adult smokers, and average radon values. The five Kentucky Counties chosen for this study were: Hancock, Henderson, Louisville-Jefferson, Rowan, and Whitley (see Table 1). The random sample from these five counties was selected via public access property roles available on the internet or hard copy from the county property valuators. Randomization was completed using the random number generator in SAS (SAS, Institute, & Inc, 2004). For the first subgroup, a radon test request coupon was attached to the mailed survey. The coupon and survey were matched by a code.

The second subgroup was a convenience sample of 143 individuals who had requested radon test kits from the Kentucky Radon Program of the Kentucky Department for Public Health, Cabinet for Health and Family Services between January to May 2009. Those included

in this sample were 121 individuals from a variety of Kentucky counties who had been on a waiting list to receive test kits following two radon television spots (one in the Louisville-Jefferson county in January, 2009 and one in Lexington-Fayette county in February, 2009), as well as 22 additional individuals who requested test kits during the month of May, 2009.

Of the 343 of the surveys mailed, 122 were returned (overall response rate of 35.6%). Of those who responded, 55 (45.1% of the total) were from the random sample (a group response rate of 27.5%), and 67 (54.9% of the total) were from the convenience sample (a group response rate of 46.9%). Four individuals from the random sample returned the coupons requesting a free test kit but did not return a completed survey and were excluded from the analysis. One individual in the random sample did not live in the county from which she was randomly selected and was excluded.

Measures

The 33 question survey consisted of a six pages containing mostly categorical, multiple-choice questions. Dependent variables included: 1) intention to test, operationalized by the stage of PAPM; and 2) the number of new radon test kits requested (random sample only). Independent variables include: perceived susceptibility, synergistic risk perception, knowledge of synergistic risk, perceived precaution effectiveness, perceived severity, social influence, and smoking status. Covariates included: age, gender, race, education, home ownership, length of residence, presence of a ground floor or basement, presence of children under age 10 living in home, age of residence, and reasons given for not testing for radon.

Intention to test

An intention to test for radon was defined as a decision to perform a radon test, as measured by the respondent's stated plan to perform the test. The outcome variable of intention to test for radon was measured by assessing the stage of PAPM into which each respondent falls. Those who responded affirmatively ("I have decided to test" or "I have already tested") to the question: "What are your thoughts about testing for radon?" indicated stages 5 and 6 of PAPM, the intention to act (Weinstein et al., 1991). The variable was dichotomized as those with and without testing intentions (stages 5-6 and stages 1-4 of PAPM, respectively). The rationale for combining stages 5 (intention to test) and 6 (already tested for radon) are justified in this study, because those who had already tested were also planning to retest for radon, as evidenced by a request for a radon test kit from the Kentucky Radon Program.

New test kit orders

The randomly selected subgroup, or those homeowners who were randomly selected to receive the study survey, were invited to request a free radon test kit from the Kentucky Radon Program. The outcome variable "new test kit orders" was defined by whether participants in this group did or did not request a free radon test kit.

Perceived susceptibility

Perceived susceptibility, one's perception about the likelihood or degree of risk from radon, was measured by the sum score of two items from a three item risk perception scale developed by Weinstein et al. (Weinstein, Lyon et al., 1998). The two items measured the respondent's perceived likelihood of having radon in ones' own home and in the home of someone else in the community. Perceived susceptibility, as measured in this study, can be equated to radon risk perception.

Synergistic risk perception

Synergistic risk perception is the view that the relative risk of tobacco smoke and radon combined is more hazardous than smoking one pack a day without radon exposure. Synergistic risk perception has been defined as the way in which the public perceive their overall risk based on the interaction or combination of several health risks (French, 2002). Synergistic risk perception was measured by single question, comparing the risk of smoking combined with radon with the risk of smoking one pack of cigarettes without radon exposure. The question asked respondents to rate the risk of the combination or smoking and radon combined compared with the risk of smoking alone using a five point scale, with response options from "much less risky" (1) to "much more risky" (5). Those who responded that the radon and smoking combination was "more risky" than smoking alone indicated their belief in an "additive" interaction, and those who indicated the combination was "much more risky" indicated a multiplicative or synergistic interaction between radon and smoking. This measure of synergistic risk perception was similar to a relative risk measure previously developed by Hampson et al. (Hampson, Andrews, Lee, Lichtenstein, & Barckley, 2000), which was a seven point scale asking participants to rate the combined risk of radon and smoking compared to the risk of smoking one pack of cigarettes without radon exposure ("many times less risky than smoking" to "many times more risky than smoking"). Hampson et al. (2000) demonstrated a multiplicative model (i.e., respondents assessed the combined risk of radon and smoking as many times greater than the risk from smoking alone) using this measure.

Knowledge of synergistic risk

Knowledge of synergistic risk was defined as knowledge of the combined hazards of radon and smoking or secondhand smoke, and was measured by the sum of four true/false items

(1= correct response, 0 = incorrect response; range 0-4). Higher knowledge scores indicated more knowledge about the combined effects of radon and tobacco smoke (both active smoking and secondhand smoke were included). This measure was modified from an existing four item scale measuring knowledge of synergistic health risk, with the permission of the original author (Hampson, Andrews, Lee et al., 2000).

Perceived precaution effectiveness

Perceived precaution effectiveness was defined as the belief that radon mitigation is a successful method for decreasing radon risk, and was measured using two questions: 1) how hard it is to reduce radon to a safe level in homes that have problems (1 = not very difficult to 4 = very difficult); and 2) how much does reducing radon levels reduce the chances of getting sick (1 = would not reduce the risk to 4 = would reduce the risk completely). These questions were modified from those previously used (Weinstein et al., 1991).

Perceived severity

Perceived severity was defined as the belief that radon-related illness would be serious. It was operationally defined by a stated belief that such an illness would be serious or very serious, as measured by one question: "How serious would an illness caused by radon be?" (Weinstein et al., 1991).

Social influence

Social influence was conceptually defined as the belief that others in one's community are concerned about radon and by the experience of peers in dealing with radon, and is measured by two questions, which ask respondents how many people they know who have tested, and how concerned about radon they believe others to be (Weinstein et al., 1991).

Smoking status

Current, former, and never smokers. Current smoking status was assessed using two questions: (1) Have you smoked at least 100 cigarettes in your entire life? (yes/no), and (2) Do you now smoke cigarettes every day, some days, or not at all (Centers for Disease Control and Prevention, 2007). Current smokers were those who had smoked at least 100 cigarettes and currently smoked every day or some days. Former smokers were those who had smoked at least 100 cigarettes but who did not smoke at all at the time of the survey. Never smokers were those who had not smoked at least 100 cigarettes in their lifetime. Questions assessing active smoking status were derived from the 2008 Behavioral Risk Factor Surveillance Survey (BRFSS) (Centers for Disease Control and Prevention, 2007).

Exposure to secondhand smoke. Exposure to secondhand smoke was assessed via self-report of exposure to tobacco smoke in the home or workplace. Three questions modified from the Nurses' Health Survey (Speizer, 1982) were utilized in order to determine previous or current exposure to tobacco smoke in the home, and current exposure in the workplace. Although self-report of smoking status may result in misclassification bias, it will provide a beginning understanding of how synergistic risk perception varies with different levels of tobacco smoke exposure.

Situational factors

Situational factors were defined as factors that are perceived to facilitate or create barriers to radon testing, and were measured by asking participants to indicate reasons for choosing not to test for radon (items listed in Table 4) (Weinstein et al., 1991). Situational factors may have the greatest impact on the transition between deciding to act and acting (Weinstein & Sandman, 1992b).

Procedures

Internal Review Board (IRB) approval was obtained from first the Kentucky Cabinet for Health and Family Services and then the University of Kentucky Medical IRB and the survey was pilot tested with six homeowners prior to the research study. Perceived length, understandability, and feasibility of the survey instrument were assessed via written comments. The few changes that were suggested were implemented. A revised survey instrument was then submitted to and approved by both IRBs.

Research study packets containing the surveys were mailed in two batches: 1) surveys and coupons for a free radon test kit were mailed to a random sample of 200 individuals from a purposive sample of 5 Kentucky counties (see Table 1), and 2) survey packets were included with radon test kits and mailed to a convenience sample of 143 individuals who requested radon test kits from the Kentucky Radon Program. The second batch was mailed through the Kentucky Radon Program, Kentucky Cabinet for Health and Family Services, and was sent out over a period of 4 weeks during May, 2009.

Several survey methods suggested by Dillman (2009) were used to increase response rates. First, an incentive in the form of a two dollar bill was attached to each survey. Second, approximately ten days after the surveys were mailed, a reminder postcard was sent to each person included in the sample (Dillman, Smyth, & Christian, 2009).

Data Analysis

Descriptive statistics were conducted, including frequency distributions or means and standard deviations, as appropriate to the level of measurement. These univariate analyses were carried out by the whole sample, subgroup (i.e., convenience and random samples), and by

outcome (i.e., those with and without testing intentions). Bivariate analysis was done between independent variables and intent to test for radon. In particular, the Rao-Scott chi-square test of association (for nominal explanatory variables and covariates), Mann-Whitney U test (for ordinal variables), or two-sample T-test (for continuous variables) was used to determine differences between those who intend to test and those who don't. Explanatory variables and covariates in the study included: perceived susceptibility, synergistic risk perception, synergistic knowledge, perceived precaution effectiveness, social influence, perceived severity, situational factors, smoking status, gender, race, education, and income. Multivariate logistic regression analysis was performed to examine the variables that were associated with intention to test. Data analysis was conducted using SAS (SAS Institute Inc., 2004) with an alpha level of 0.05 throughout. Given the data were obtained using a complex survey design, SAS procedures appropriate for this type of design, including SURVEYFREQ, SURVEYMEANS, and SURVEYLOGISTIC, were used.

Results

Sample characteristics

Overall, participants lived in 17 different Kentucky counties, with 45.1% of the total sample residing in Jefferson County. The mean age of the total sample was 52.1 years and the majority was female with an annual household income of at least $50,000, college graduate, Caucasian, and non-smoker (see Table 2). All but two respondents reported being Caucasian: one Asian and one Hispanic (both in the convenience sample). Approximately 44% of the participants had smoked at some point in their lifetime, although only 8% were current smokers. The number of years current or former smokers had smoked averaged 17.8 (s.e.m. 2.0). Almost one third (36 or 31.9%) of respondents reported some current secondhand smoke (SHS) exposure

either at work or at home. The mean number of children aged 10 or less per household was 0.4 (s.e.m. = 0.1), with 26.2% (32) of the total sample having children 10 years and younger at home. The mean number of years lived in their current residences was 13.0 years (s.e.m. = 1.1), and the average age of the participants' residences was 31.4 years (s.e.m. = 2.3). Most reported having a ground floor or basement in their residence (99 or 81.8%). All but one respondent reported owning their home or residence.

Comparisons of convenience and random samples

There were no significant differences between the convenience and random samples in terms of age, gender, income, education, race, or smoking status (see Table 2). The random sample came from 5 counties, as described in the methods above. The convenience sample resided in 15 different counties, with the majority (62.7%) living in Jefferson county.

Radon awareness. There was a significant difference between the convenience and random samples in radon awareness (see Table 2). The random sample had more individuals who were unaware, or who had never thought about radon testing. Over half of the participants had heard of radon via television. Other common sources of information about radon included newspaper, magazine, radio, and family, friends, co-workers, neighbors. The random and convenience samples were similar in their sources of radon information, except, unlike the convenience sample, several in the random sample reported having heard about radon at work, and some reported never having heard of radon. One individual from the convenience sample reported being a licensed home inspector with certification to test for radon. There were no significant differences in knowledge of synergistic risk between those in the random and convenience samples ($t = 0.78$, $p = 0.4$).

Reasons for obtaining a test kit. A majority of the total sample (57.0%) reported obtaining the radon test kit because it was free; there was a significant difference between the random and convenience samples in the number who reporting obtaining the kit because it was free ($\chi^2 = 9.51$, $p < 0.01$). Twelve respondents obtained a test kit because a family member had lung cancer, 8 reported having a friend with lung cancer, and 5 respondents reported a personal history of lung cancer. Suggestions from friends, neighbors, family members, and health care providers all resulted in test kit orders. Three respondents from the total sample reported obtaining a test kit after having considered doing so for some time. For example, one participant wrote, "After being knowledgeable about radon for years, I decided to get a test kit!" Another reported that he had "heard of radon for years" and stated "[I] can't remember why I finally decided to get [a] test kit except it was free and concern if [I have a] high level [of radon I] will get lung cancer if don't do something about it. A third participant stated, "radon is out of [sight] out of mind…I should have done it [tested] but haven't." Other reasons given for obtaining a kit include real estate transactions (2), an internet search (1), and "did not know radon was a health problem."

Reasons for not *testing for radon (i.e., situational factors)*. Over a third (38%) of the total sample reported that they did not test because they did not believe they had a radon problem in their home (see Table 4). Six respondents cited lack of knowledge (in the write-in 'other' response) as the reason they did not test. One wrote that he was "too illiterate." Others wondered if the test would give a "true result" and if an elevated result would make it "harder to sell our house." One responded, "…just another abstract, intangible thing to be stressed out about…ignorance is bliss!"

Comparisons by intention to test

There were no significant differences in mean age between those who planned to test and those who did not ($t = 0.41$, $p = 0.7$). There were no differences in gender, income, race, smoking status, or the presence of children under age 10 in the home (see Table 3) between those with and without testing intentions. There was, however, a significant difference in education between those who planned to test and those who did not. There was also a significant difference between groups in those reporting the presence of a ground floor or basement in their homes ($\chi^2 = 4.30$, $p = 0.04$). There was no statistically significant difference between those who tested and those who did not in the mean number of years respondents reported living in their current residences ($t = 1.03$, $p = 0.3$), or in the mean residence age ($t = -1.94$, $p = 0.1$).

Over half (69 or 63.3%) of those who had heard of radon indicated intentions to test for radon. One respondent who had mitigated (and therefore already tested for radon) did not plan to test again. Three respondents indicated that they had already mitigated but planned to (re)test for radon. Thus, it can be assumed that all of those in PAPM stage five or six had testing intentions, justifying the use of a dichotomous outcome variable.

Income (<$50,000 versus ≥ 50,000) was significantly related to education (< college graduate versus ≥ college graduate) ($\chi^2 = 6.61$, $p = 0.01$); therefore, education was selected to represent socioeconomic status, excluding income from the regression model. Race was also eliminated from the regression since there were only 2 respondents who were not Caucasian. Due to a marginal association between presence of a ground floor or basement in one's home and education level ($\chi^2 = 2.99$, $p = 0.08$), both variables were not included in the regression, so as to minimize the likelihood of multi-collinearity. Education was selected from these two variables,

as it conceptually would be more likely to be related to the outcome (i.e., intention to test for radon).

Perceived susceptibility. Perceived susceptibility was significantly higher in the group that planned or had already tested for radon than in the group not planning radon testing ($z = -4.37$, $p < 0.001$). The two components of perceived susceptibility, perceived likelihood of a radon problem in one's home and the perceived percentage of radon problems in one's area, both had significant differences between those with and without testing intentions (see Table 4).

Synergistic risk perception. Synergistic risk perception was significantly different in the group that planned to test or had already tested, compared with those in the other PAPM stages ($z = -2.18$, $p = 0.03$). There were no significant differences in synergistic risk perception between ever smokers and never smokers ($z = -0.81$, $p = 0.2$), current smokers and others ($z = -1.50$, $p = 0.1$), former smokers and others ($z = 0.10$, $p = 0.9$), or between those who were or were not currently exposed to secondhand smoke (at home or at work) ($z = -0.80$, $p = 0.4$). When synergistic risk perception was dichotomized by those who indicated a multiplicative interaction (i.e., those who answered the combination of radon and smoking is "much more risky" than smoking alone) versus all other responses, there was a significant difference in the frequency of those reporting a multiplicative interaction among those who reported testing intentions versus those who did not ($\chi^2 = 6.94$, $p = 0.01$). This dichotomized synergistic risk perception variable was used for the logistic regression.

Synergistic knowledge score. The average knowledge score for the combined group was 3.0 (s.e.m. = 0.1), with no significant differences between those with and without testing intentions ($t = -1.49$, $p = 0.1$). There was a significant relationship between synergistic risk perception and knowledge score ($F = 3.98$, $p < 0.01$).

Perceived precaution effectiveness. Perceived precaution effectiveness, was measured by two ordinal level variables, perceived effectiveness of mitigation in decreasing radon risk, and the perceived ease of mitigation. Ease of mitigation was not significantly different between the groups ($z = 1.46$, $p = 0.1$). Perceived effectiveness of mitigation was significantly different between those who intended to test and those who did not ($z = -2.29$, $p = 0.02$). However, because the effectiveness of mitigation variable had only three categories, it could not be entered into the regression as an ordinal variable, and it could not be used as a dichotomous variable (i.e., would not take away risk versus would partially or completely take away risk from radon). Only six individuals in the total sample (5.0%) believed that mitigation was not effective in reducing risk from radon. Thus, due to limited variability in the responses, perceived precaution effectiveness was not included in the regression model.

Social influence. Community concern was collapsed from a four categories to three by combining "concerned" and "very concerned" into one category, since one of the cells was zero, limiting the comparison between groups. Community concern, both as a 3 category variable and as a dichotomous variable, was significantly different between groups based on testing intentions. The average number of known households who had tested for radon and the knowing someone who had tested was significantly different between those who planned to test and those who did not ($t = -2.45$, $p = 0.02$).

College graduates and those with higher perceived susceptibility, perceived severity, and those who knew others who had tested for radon and perceived that others in their community were concerned about radon had higher odds of testing intentions (see Table 5). Those who had graduated from college had 3.7 times higher odds of planning to test for radon than those who did not plan to test (OR 3.67, 95% CI 1.10-12.27). The perception of radon-related illness as

being serious or very serious was associated with > 8 times higher odds of planning to test for radon (OR 8.25, 95% CI 2.46-27.73). Knowing others who tested and a perception of community concern about radon were also associated with radon testing intentions. There was no association between radon testing intentions and synergistic risk, smoking status, gender, or age. When current exposure to secondhand smoke was used as a proxy for smoking, this variable was not associated with radon testing intentions.

Request for free radon test kit in random sample and PAPM stage

Most (40 or 72.7%) of participants in the random sample requested a free radon test kit. There was not a significant relationship between requesting a free test kit and reporting testing intentions ($\chi^2 = 2.29$, $p = 0.1$).

Discussion

College graduates were more likely to have radon testing intentions than those with less education, although there were no differences in age, gender, income, race, smoking status, the presence of children under age 10 in the home, or synergistic knowledge between those with and without testing intentions. All but two of the participants were Caucasian, so the effect of race on testing intentions could not be analyzed in this study. Perceived susceptibility, perceived severity, knowing others who tested for radon, and perceived community radon concern were all positively associated with radon testing intentions. Synergistic risk perception was not associated with radon testing intentions in the regression analysis. Contrary to the study hypothesis, females were not more likely to plan to test for radon than males. There were also no significances differences between males and females in perceived susceptibility or synergistic risk perception.

Intention to test for radon

Perceived susceptibility. As hypothesized, perceived susceptibility was significantly higher in the group that planned or had already tested for radon. The two components of perceived susceptibility, likelihood of a radon problem in one's home and the percentage of radon problems in one's area, were both significantly different when those who planned to test were compared to those who did not. Similarly, both the belief that there was not a radon problem in one's home and the belief that there was not a radon problem in one's area were given as reasons for not testing significantly more frequently in those not planning to test for radon than among those with testing intentions. This was an expected finding, since perceived susceptibility has been previously cited as a prerequisite to radon testing intention and behavior (Duckworth, Frank-Stromborg, Oleckno, Duffy, & Burns, 2002; Weinstein, 1988; Weinstein & Sandman, 1992a).

It is important to note that more participants reported that they did *not* "think I have a problem [their] in my home" than that there were "no problems in [their] my area" as reasons for not testing (36.1% and 23.8%, respectively). This finding is congruent with another study reporting 43% of respondents cited perceived lack of a radon problem in their home as a reason for not testing for radon (Kennedy, Probart, & Dorman, 1991), and others that report that respondents rate environmental hazards as riskier for others than for themselves (Park, Scherer, & Glynn, 2001). This finding points to an important consideration for future intervention. Communication about risk from radon should not only seek to increase general public knowledge about radon risk, but also provide geographic-specific information regarding risk in one's geographic area. This finding is confirmed by a study demonstrating that individuals who

were aware that they lived in a high radon area were more likely to test for radon (Wang et al., 2000).

Perceived severity. Those who perceived that the illness caused by radon would be serious or very serious were more than eight times more likely to plan radon testing than those who thought it was not serious or somewhat serious. This finding is congruent with previous work demonstrating a significant correlation between perceived illness severity and radon testing intentions (Weinstein et al., 1991).

Synergistic risk perception. Contrary to the study hypothesis, synergistic risk perception was not significantly associated with testing intentions. Most of the respondents had an inaccurate understanding of the combined risks of radon exposure and smoking, and more of them rated the combination as "more risky" rather than as "much more risky." The former describes an additive interaction between smoking and radon, and the later describes a more accurate multiplicative or synergistic interaction. Further, when the variable was dichotomized for the regression ("much more risky" = 1, other responses = 0), respondents with the correct understanding of synergistic risk (i.e., the combination of radon and smoking are much more risky than smoking alone) were not more likely to intend to test for radon.

The lack of a perceived multiplicative interaction between radon and smoking has been previously cited in the literature (Hampson et al., 1998; Hampson, Andrews, Lee et al., 2000). It is unclear whether this lack of perceived multiplicative interaction is more a function of incomplete knowledge of the sample or the degree of accuracy of the measures than of the attitudes and beliefs related to risk. For example, a study by Bonnin-Scaon et al. indicates that participants who where retested, subsequent to education on the synergy of radon and smoking, moved from a sub-additive (i.e., the combined risk of radon and smoking is *less* than the risk

from smoking) to a multiplicative model of risk perception (Bonnin-Scaon, 2002). In this study, synergistic risk perception and knowledge score were related, and knowledge score was not significantly different between those who did and did not intend to test. These findings lend credence to the premise that the lack of an accurate understanding of synergistic risk is related to incomplete knowledge.

Others, however, have reported that participants gave different synergistic risk estimates for themselves than for others in their home or in their neighborhood, regardless of the same actual risk (Hampson et al., 1998). Unrealistic optimism, where individuals are more concerned with health risk for society at large than for themselves personally, has been reported in relation to risks such as contaminated drinking water, AIDS, heart disease, and radon (Park et al., 2001). For example, some do not test their homes for radon because they believe they are less at risk than those around them, regardless of their actual risk. Further study is needed to examine the combined effect of both knowledge and optimistic bias on the measurement of synergistic risk perception.

Synergistic risk perception was not found to be significantly different based on smoking status with neither current nor former or ever smokers, nor with those currently exposed to secondhand smoke. Having ever smoked at least 100 cigarettes in one's life was not associated with radon testing intentions or synergistic risk perception. A larger sample size with more smokers is needed to assess for differences in synergistic risk perception between current smokers and nonsmokers, as there were only 12 current smokers in this study. Several studies have reported less concern about radon by smokers than nonsmokers (Kennedy et al., 1991; Mainous & Hagen, 1993), and suggested that health education strategies be focused on smokers.

Increasing the concern of smokers about radon, and specifically about the combined risk of radon and smoking is an important area for future intervention research.

Social influence. A number of individuals (35.2%) reported hearing about radon from family members, friends, neighbors, or co-workers. Knowing others who tested for radon and having a perception that community members are concerned about radon were both associated radon testing intentions. The actions or accounts of others, such as family, friends, or neighbors, may influence individuals to transition from being unengaged with radon as a health hazard (stage two of PAPM) to deciding to take action (Weinstein, 1988; Weinstein & Sandman, 2002).

Media. The role of the media, especially television, on increasing knowledge about radon and prompting test kit orders is an important finding in this study. Over half of the total sample and convenience sample had heard of radon through television. The convenience sample consisted of individuals who requested a kit following two local television spots on radon, so this finding is unsurprising. However, almost half (47.3%) of the random sample had also heard about radon by television. Other media sources radon information included magazine, newspaper, and radio. Media may be an important venue for dispersing the joint smoking and radon risk message. Working to decrease smoking rates, household smoking, and residential radon exposure together would be a cost effective manner to address major lung cancer risk factors, thereby decreasing lung cancer incidence in Kentucky.

Free test kits. Many of the respondents reported that they obtained a radon test kit because it was free. While this study does not address the number of these respondents who will follow through with testing and mitigation if indicated, it does point out an important issue for state radon programs. Offering a free test kit may be a valid strategy for promoting or prompting residential radon testing or at least the order of a test kit. For those who have already decided to

test for radon, interventions that increase the ease of radon testing (i.e., through the provision of information and/or a test kit) are more effective at increasing test kit orders than interventions that increase risk perception (Weinstein, Lyon, Sandman, & Cuite, 1998; Weinstein et al., 1990, 1991). Further research is needed to find effective ways to motivate those obtaining free test kits to return the test kit and then mitigate if radon levels are elevated. Implementing policy that requires radon testing, reporting, and mitigation as part of real estate transactions has been suggested as one way of increasing the effectiveness of programs than distribute free test kits (Field, Kross, & Vust, 1993).

Test kit orders

Those in the convenience sample had all requested radon kits prior to the receipt of their survey packets, and thus, their intention to test for radon is assumed. However, radon testing intentions (i.e. stage of testing) were not significantly associated with radon test kit orders when the analysis included only those in the random group. There are several possible explanations for this. First, some respondents may have requested the test kit simply because it was free, even if they did not plan on using the kit. This is suggested by the significant relationship between those who reported obtaining the test kit because it was free and those who ordered the kit ($\chi^2 = 4.04$, $p = 0.04$). Second, there may have been temporal issues that are impossible to decipher. This is because the coupon for the free test kit was included in the survey packet due to time constraints and as approved by the Kentucky Cabinet for Health and Family Services Internal Review Board. Since the coupon insertion in the research packet was a sort of intervention, it is difficult to determine if the PAPM stage of testing reported by the respondent was the same stage the respondent was in when the coupon for the free kit was returned. Weinstein noted that direction of causality for factors related to or predictive of test kit orders would be clearer if the

test kit is not offered until after the survey is returned (Weinstein et al., 1990). This is an important consideration for future prospective studies.

Limitations

Selectional bias is a possible limitation in this study. The Kentucky Radon Program does not currently have the ability to obtain test results from tests purchased from commercial sources, such as home improvement stores. Therefore, the study sample, particularly those in the convenience subsample, may not represent the general population of individuals who elect to test their homes for radon, which may decrease the generalization of the study findings. Selection bias may also result if the individuals who chose to participate in this study are different than those who did not. For example, study participants in the random sample were more likely to have graduated from college and had higher incomes than most in their respective counties (see Table 1). It is also important to note the small number of individuals who were current smokers in this study. The primary reason that this sample had a higher socioeconomic status and lower smoking rate than the general population is that only homeowners were selected for inclusion in this study, and those higher a socioeconomic status are more likely to be homeowners (Haurin, Herbert, & Rosenthal, 2007). Although survey methods were used to increase response rates (Dillman et al., 2009), the relatively low response rate limits the generalization of the study findings. Those who chose to respond to the survey may have had more knowledge about radon and would have been more familiar with radon testing than non-responders, which may have biased survey responses.

Two additional factors in the sample bias the study results. First, there were five participants who reported having lung cancer, which was 4.1% of the sample. Individuals with a personal or family history of lung cancer may have been more likely to be selected for this

sample because they were more likely to request a test kit from the Kentucky Radon Program or more likely to respond to the survey packets sent to those randomly selected from the five counties. Individuals with a history of exposure (i.e. to lung cancer) may respond to risk information differently than others (Smith & Johnson, 1988). Second, although all of those receiving a radon test kit were given a copy of the EPA publication "A Citizen's Guide to Radon," those in the convenience sample were given this information in the same mailing as the research survey packet, as per standard protocol of the Kentucky Radon Program. Although participants were instructed to answer the survey questions according to their thoughts about radon prior to receiving the research survey packet, this informational brochure may have impacted their survey responses.

A final limitation of this study is its cross-sectional design. Although this study provides important information about associations between study variables and intentions to test for radon, it is unable to provide predictions about directional causality. Further research utilizing prospective design is needed to determine the impact of study variables, particularly synergistic risk perception, on the transition between stages of the adoption of radon testing behavior.

Conclusion

There are three areas in which this study contributes to existing knowledge. First, this study demonstrates that lack of perceived susceptibility, primarily the lack of belief that there is a radon problem in one's home, contributed to decisions not to test for radon. Second, synergistic risk perception (i.e. the perception about the combined risk of tobacco smoke and radon exposure) was not significantly related to radon testing intentions, and most respondents did not correctly understand the synergistic relationship between smoking and radon. There were no differences in synergistic risk perception or testing intentions based on smoking status. Further

research is needed to investigate the influence of synergistic risk perception on radon testing behaviors in current and former smokers. Third, this study identifies factors related to radon testing intentions among Kentucky homeowners, including social influence, the prompt of a free test kit, and the impact of media outreach on increasing radon testing. These findings will be utilized to increase residential radon testing and decrease lung cancer risk among Kentucky homeowners.

Acknowledgments

This study was a collaborative effort with the Kentucky Radon Program, Kentucky Cabinet for Health and Family Services. Many thanks to my dissertation committee co-chairs, Dr. Ellen Hahn and Dr. Mary Kay Rayens, for their guidance in this project.

Figure 1.
Application of the Precaution Adoption Process Model to Radon Risk Reduction

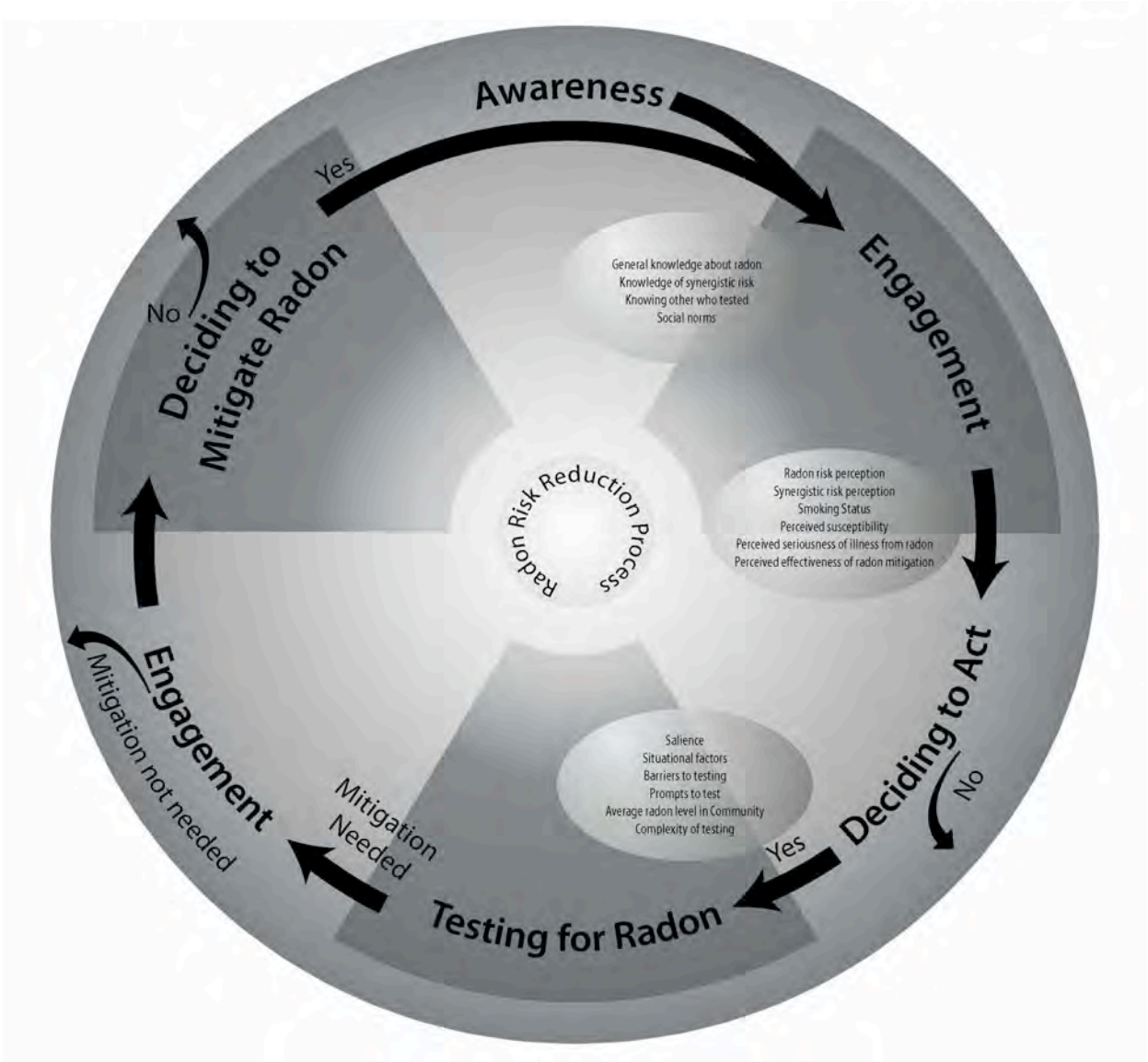

Figure 2.
Factors associated with residential radon testing intentions: Study protocol

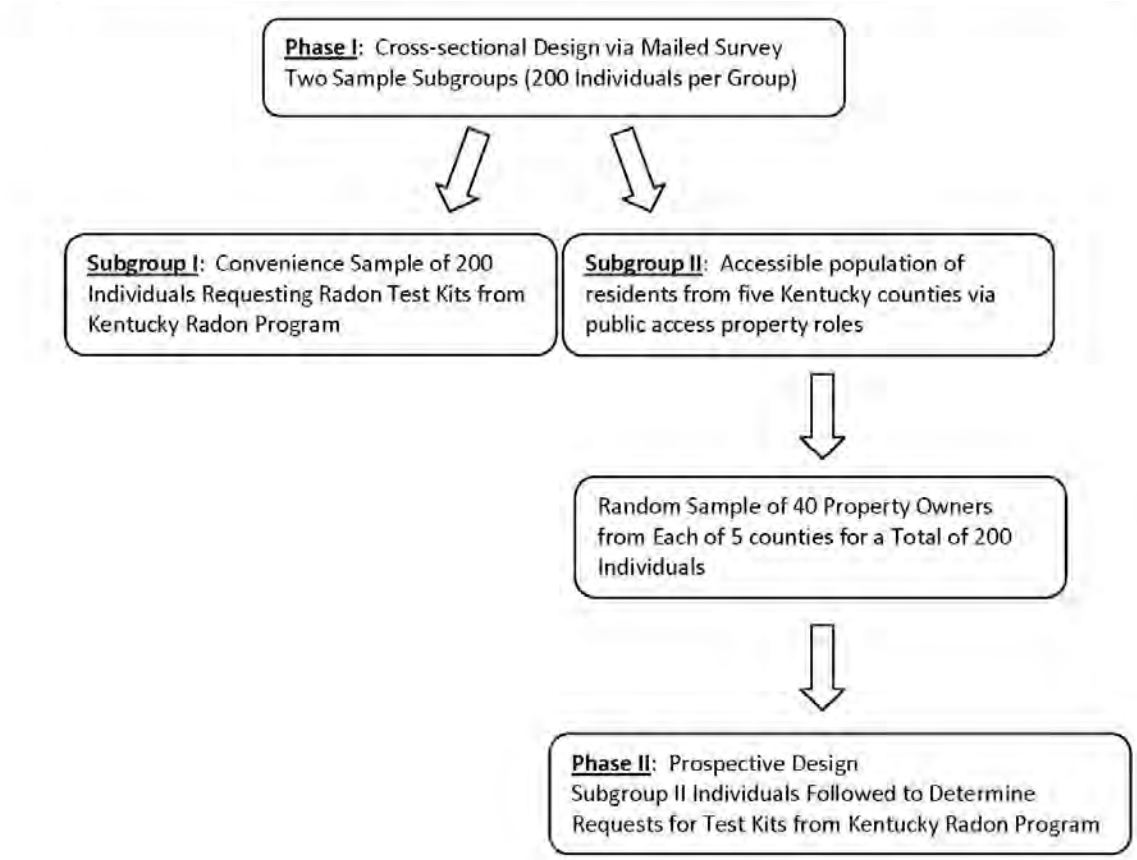

Table 1.
Purposive sample of five Kentucky counties for random group

County	*Rural*[1]	*2000 Census Population*[2]	*Region of Kentucky*	*Received Radon Outreach in past few years*[3]	*Percent Adult Smoking (2000-2004)*[4]	*Radon Average pCi/L (2000-2004)*[3]	*Lung Cancer Incidence (2000-2004)*[5]	*Median Household Income*[6]	*Percent college graduates*[7]
Hancock	Yes	8,392	Western	No	18.1%	3.00	115.13	$47,558	8.1%
Henderson	No	44,829	Western	No	33.7%	1.84	92.96	$41,692	13.8%
Louisville-Jefferson	No	693,604	Central	Yes	25.2%	6.43	99.54	$43,677	24.8%
Rowan	Yes	22,094	Eastern	No	27.6%	1.39	87.42	$34,278	21.9%
Whitley	Yes	35,865	Eastern	No	33.2%	2.11	121.45	$27,424	13.4%

[1] Economic Research Service Rural-Urban Commuting Areas (rural defined as RUCA codes 4-10) http://www.ers.usda.gov/data/ruraldefinitions/KY.pdf
[2] U.S. Census Bureau, 2000
[3] Kentucky Radon Program
[4] BRFSS, 2000-2004
[5]Kentucky Cancer Registry, 2000-2004 age-adjusted incidence rate
[6]U.S. Census Bureau, 2007
[7]Percentage of individuals aged 25 or older with a Bachelor's degree or higher, U.S. Census Bureau, 2000

Table 2.
Descriptive statistics and group comparisons between random and convenience samples: Percentages and frequencies ($N = 122$)

	Total[1]	Convenience Sample ($n = 67$)	Random Sample ($n = 55$)	Test Statistic[2]
Gender				$\chi^2 = 0.00$
Female	62.2% (74)	61.2% (41)	60.0% (33)	
Male	37.8% (45)	37.3% (25)	36.4% (20)	
Annual Household Income				$\chi^2 = 1.53$
< $50,000	28.2% (31)	20.9% (14)	30.9% (17)	
≥ $50,000	71.8% (79)	68.7% (46)	60.0% (33)	
Education Level				$\chi^2 = 2.14$
< College Graduate	49.2% (58)	41.8% (28)	54.5% (30)	
≥ College Graduate	50.8% (60)	55.2% (37)	41.8% (23)	
Race				
Caucasian	98.3% (117)	95.5% (55)	96.4% (53)	
Minority	1.7% (2)	3.0% (2)	-------	
Smoking Status				
Current Yes	10.0% (12)	9.0% (6)	10.9% (6)	$\chi^2 = 0.13$
No	90.0% (108)	89.6% (60)	87.3% (48)	
Former Yes	35.0% (42)	35.8% (24)	32.7% (18)	$\chi^2 = 0.12$
No	65.0% (78)	62.7% (42)	65.5% (36)	
Never Yes	55.0% (66)	53.7% (36)	54.5% (30)	$\chi^2 = 0.01$
No	45.0% (49)	44.8% (30)	43.6% (24)	
How much heard about radon				$\chi^2 = 12.15$*
Nothing	11.5% (13)	3.0% (2)	9.7% (11)	
A little bit	28.7% (35)	25.4% (17)	32.7% (18)	
Some	49.2% (60)	59.7% (40)	36.4% (20)	
A great deal	11.5% (14)	11.9% (7)	10.9% (6)	

[1]Sum may not equal N (122) and percentage may not equal 100% due to missing values
[2] Group comparisons based on Rao-Scott chi-square test
* $p < 0.05$

Table 3.
Descriptive statistics and group comparisons between those who planned to test and those who did not: Percentages and frequencies ($N = 122$)

	Total[1]	Planning to Test[2] ($n = 69$)	*Not* Planning to Test ($n = 53$)	Test Statistic[3]
Gender				$\chi^2 = 0.07$
Female	62.2% (74)	62.3% (43)	58.5% (31)	
Male	37.8% (45)	36.2% (25)	37.7% (20)	
Annual Household Income				$\chi^2 = 1.70$
< $50,000	28.2% (31)	21.7% (15)	30.2% (16)	
≥ $50,000	71.8% (79)	71.0% (49)	56.6% (30)	
Education Level				$\chi^2 = 8.69$**
< College Graduate	49.2% (58)	36.2% (25)	62.3% (33)	
≥ College Graduate	50.8% (60)	60.9% (42)	34.0% (18)	
Race				
Caucasian	98.3% (117)	95.7% (66)	96.2% (51)	
Minority	1.7% (2)	2.9% (2)	--------	
Smoking Status				
Current				$\chi^2 = 0.02$
Yes	10.1% (12)	10.2% (7)	9.4% (5)	
No	91.9% (102)	88.4% (61)	88.7% (47)	
Former				$\chi^2 = 1.17$
Yes	35.0% (42)	30.4% (21)	39.6% (21)	
No	65.0% (78)	61.8% (47)	58.5% (31)	
Never				$\chi^2 = 0.93$
Yes	55.0% (66)	58.0% (40)	49.1% (26)	
No	45.0% (54)	40.6% (28)	49.1% (26)	
Current secondhand smoke exposure at home *or* work				$\chi^2 = 0.69$
Yes	31.9% (36)	27.5% (19)	32.1% (17)	
No	68.1% (77)	68.1% (47)	56.6% (30)	
Children under 10 in household				$\chi^2 = 0.00$
Yes	26.2% (32)	26.1% (18)	26.4% (14)	
No	73.8% (90)	73.9% (51)	73.6% (39)	

[1]Sum may not equal N (122) due to missing values
[2] "Planning to test" indicates those in Precaution Adoption Process Model stages 5 and 6
[3]Group comparisons based on Rao-Scott chi-square test
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 4.
Reasons given for not testing for radon: Percentages, frequencies, and comparisons between groups ($N = 122$)

	Total	Planning to Test ($n = 69$)	*Not* Planning to Test ($n = 53$)	Rao-Scott Chi-Square Test
Radon risk is exaggerated	10.7% (13)	11.6% (8)	9.4% (5)	0.17
No radon problems in my area	23.8% (29)	13.0% (9)	37.7% (20)	9.81**
Don't think I have a problem in my home	36.1% (44)	21.7% (15)	54.7% (29)	13.73***
Neighbor's readings are low	0.8% (1)	--------	1.9% (1)	
Will wait to see what others in the community find	9.8% (12)	4.3% (3)	17.0% (9)	5.27*
Not interested	9.0% (11)	7.2% (5)	11.3% (6)	0.57
Getting rid of radon would be too hard/expensive	23.8% (29)	27.5% (19)	18.9% (10)	1.35
Didn't know it was possible to test	14.8% (18)	10.1% (7)	20.8% (11)	2.57
Don't know what testing method is best	21.3% (26)	15.9% (11)	28.3% (15)	3.00
Don't know how to get a radon test kit	26.2% (32)	20.3% (14)	34.0% (18)	2.74
Costs too much to test	16.4% (20)	14.5% (10)	18.9% (10)	0.37
Results won't be kept confidential	3.3% (4)	2.9% (2)	3.8% (2)	0.06
Haven't gotten around to it	25.4% (31)	27.5% (19)	22.6% (12)	0.44
Takes too long to get test results	4.9% (6)	2.9% (2)	7.5% (4)	1.34
Already decided to test or have tested	29.5% (36)	50.7% (35)	1.9% (1)	35.04***
Other reason	9.0% (11)	7.2% (5)	11.3% (6)	0.57

Participants were asked to select all responses that were applicable, so percentages do not equal 100%.
* $p < 0.05$; ** $p < 0.01$; *** $p < 0.001$

Table 5.
Factors associated with radon testing intentions among Kentucky homeowners ($N = 122$)

	OR	95% Confidence Interval
Age	1.00	(0.99, 1.00)
Gender		
Female	1.71	(0.51, 5.77)
Male	*	
Education		
≥ College Graduate	3.67	(1.10, 12.27)
< College Graduate	*	
Current smoking		
Yes	4.15	(0.65, 26.61)
No	*	
Perceived susceptibility	1.82	(1.12, 2.96)
Synergistic risk perception		
Yes	3.01	(0.90, 10.02)
No	*	
Perceived severity		
Serious or very serious	8.25	(2.46, 27.73)
Not serious or somewhat serious	*	
Know others who have tested for radon		
Yes	6.31	(2.09, 19.04)
No	*	
Perceived community concern about radon		
Yes	3.68	(1.16, 11.69)
No	*	

* Reference Group

References

Bonnin-Scaon, S., Lafon, P., Chasseigne, G., Mullet, E., & Sorum, P. C. (2002). Learning the relationship between smoking, drinking alcohol, and the risk of esophageal cancer. *Health Education Research, 17*(4), 415-424.

Centers for Disease Control and Prevention. (2007). *2008 BRFSS questionnaire*. Atlanta: Centers for Disease Control and Prevention.

Centers for Disease Control and Prevention. (2008). BRFSS prevalence data-tobacco use 2008. Retrieved August 4, 2009, from http://apps.nccd.cdc.gov/BRFSS/list.asp?cat=TU&yr=2008&qkey=4396&state=All.

Dillman, D. A., Smyth, J. D., & Christian, L. M. (Eds.). (2009). *Internet, mail, and mixed-mode surveys: The tailored design method* (3rd ed.). Hoboken, NJ: John Wiley & Sons., Inc.

DiPofi, J. A., LaTour, M. S., & Henthorne, T. L. (2001). The new social marketing challenge to promote radon testing. *Health Mark Q, 19*(1), 79-90.

Duckworth, L. T., Frank-Stromborg, M., Oleckno, W. A., Duffy, P., & Burns, K. (2002). Relationship of perception of radon as a health risk and willingness to engage in radon testing and mitigation. *Oncology Nursing Forum, 29*(7), 1099-1107.

Environics Research Group. (2007). *2007 National radon and indoor air quality survey* (No. HC POR-06-94). Ottawa, Ontario, Canada: Health Canada.

Environmental Protection Agency. (2009). *A citizen's guide to radon: The guide to protecting yourself and your family from radon* (No. EPA 402/K-09/001). Washington, D. C.: Environmental Protection Agency.

Environmental Protection Agency. (n.d.). Map of radon zones for Kentucky. Retrieved June 30, 2009, from http://www.epa.gov/radon/states/images/kentucky.gif.

Field, R. W., Kross, B. C., & Vust, L. J. (1993). Radon testing behavior in a sample of individuals with high home radon screening measurements. *Risk Analysis, 13*(4), 441-447.

French, D. P., Gayton, E. L., Burton, J., Thorogood, M., & Marteau, T. M. (2002). Measuring perceptions of synergistic circulatory disease risk due to smoking and the oral contraceptive pill. *Risk Analysis, 22*(6), 1139-1151.

Gregory, B., & Jalbert, P. P. (n.d.). *National radon results: 1985 to 2003*. Washington, D.C.: Environmental Protection Agency.

Halpern, M. T., & Warner, K. E. (1994). Radon risk perception and testing: Sociodemographic correlates. *Journal of Environmental Health, 56*(7), 31-35.

Hampson, S. E., Andrews, J. A., Barckley, M., Lichtenstein, E., & Lee, M. E. (2000). Conscientiousness, perceived risk, and risk-reduction behaviors: A preliminary study. *Health Psychology, 19*(5), 496-500.

Hampson, S. E., Andrews, J. A., Lee, M. E., Foster, L. S., Glasgow, R. E., & Lichtenstein, E. (1998). Lay understanding of synergistic risk: The case of radon and cigarette smoking. *Risk Analysis, 18*(3), 343-350.

Hampson, S. E., Andrews, J. A., Lee, M. E., Lichtenstein, E., & Barckley, M. (2000). Radon and cigarette smoking: Perceptions of this synergistic health risk. *Health Psychology, 19*(3), 247-252.

Haurin, D. R., Herbert, C. E., & Rosenthal, S. S. (2007). Home ownership gaps among low-income and minority households. *Citiscape: A Journal of Policy Development and Research, 9* (2), 5-52.

Hill, W. G., Butterfield, P., & Larsson, L. S. (2006). Rural parents' perceptions of risks associated with their children's exposure to radon. *Public Health Nursing, 23*(5), 392-399.

Kennedy, C. J., Probart, C. K., & Dorman, S. M. (1991). The relationship between radon knowledge, concern and behavior, and health values, health locus of control and preventive health behaviors. *Health Education Quarterly, 18*(3), 319-329.

Kentucky Cabinet for Health and Family Services. (2004). Kentucky radon zone map. Retrieved June 30, 2009, from http://chfs.ky.gov/NR/rdonlyres/F4045C71-D661-4686-93F2-F25003397B6D/0/KentuckyCountiesMap1.pdf.

Lichtenstein, E., Boles, S. M., Lee, M. E., Hampson, S. E., Glasgow, R. E., & Fellows, J. (2008). Using radon risk to motivate smoking reduction II: Randomized evaluation of brief telephone counseling and a targeted video. *Health Education Research, 23*(2), 191-201.

Mainous, A. G., 3rd, & Hagen, M. D. (1993). Public perceptions of radon risk. *Family Practice Residency Journal, 13*(1), 63-69.

National Cancer Institute. (2007). SEER Cancer Statistics: Cancer of the Lung and Bronchus. Retrieved October 10, 2007, from http://seer.cancer.gov/statfacts/html/lungb.html?statfacts_page=lungb.html&x=15&y=16.

National Cancer Institute. (2008). Incidence rates table: Lung & bronchus cancer. Retrieved August 4, 2009, from http://statecancerprofiles.cancer.gov/cgi-bin/quickprofiles/profile.pl?21&047.

National Research Council. (1999). *Health effects of exposure to radon: BEIR VI*. Washington, D.C.: National Academy Press.

Park, E., Scherer, C.-W., & Glynn, C.-J. (2001). Community involvement and risk perception at personal and societal levels. *Health, Risk and Society, 3*(3), 281-292.

Sandman, P. M., & Weinstein, N. D. (1993). Predictors of home radon testing and implications for testing promotion programs. *Health Education Quarterly, 20*(4), 471-487.

SAS, Institute, & Inc. (2004). SAS 9.1.2. Cary, NC: SAS Institute Inc.

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

Speizer, F. E. (1982). Nurses' health study questionnaire. Boston: Harvard Medical School.

Wang, Y., Ju, C., Stark, A. D., & Teresi, N. (2000). Radon awareness, testing, and remediation survey among New York State residents. *Health Physics, 78*(6), 641-647.

Weinstein, N. D. (1988). The precaution adoption process. *Health Psychology, 7*(4), 355-386.

Weinstein, N. D., Lyon, J. E., Sandman, P. M., & Cuite, C. L. (1998). Experimental evidence for stages of health behavior change: the precaution adoption process model applied to home radon testing. *Health Psychology, 17*(5), 445-453.

Weinstein, N. D., & Sandman, P. M. (1992a). A model of the precaution adoption process: Evidence from home radon testing. *Health Psychology, 11*(3), 170-180.

Weinstein, N. D., & Sandman, P. M. (1992b). Predicting homeowners mitigation responses to radon test data. *Journal of Social Issues, 48*(4), 63-83.

Weinstein, N. D., & Sandman, P. M. (2002). The precaution adoption process model. In K. Glanz, Rimer, B. K., & Lewis, F. M. (Ed.), *Health behavior and health education: Theory, research, and practice* (pp. 121-143). San Francisco: Jossey-Bass.

Weinstein, N. D., Sandman, P. M., & Roberts, N. E. (1990). Determinants of self-protective behavior: Home radon testing. *Journal of Applied Social Psychology, 20*(10), 783-801.

Weinstein, N. D., Sandman, P. M., & Roberts, N. E. (1991). Perceived susceptibility and self-protective behavior: A field experiment to encourage home radon testing. *Health Psychology, 10*(1), 25-33.