Personalized Report-Back to Renters on Radon and Tobacco Smoke Exposure

Ellen J. Hahn, PhD, RN, FAAN
Kathy Rademacher
Amanda Wiggins, PhD
Mary Kay Rayens, PhD
University of Kentucky College of Nursing

Abstract **Combined exposure to tobacco smoke and radon increases lung cancer risk, and renters are disproportionately exposed to secondhand smoke (SHS). A quota sample of renters (N = 47) received free radon and airborne nicotine test kits in a primary care setting to explore the impact of a personalized environmental report-back intervention on home exposure. Half of the sampled renters reported smokers living in the home. Taking actions to reduce radon and SHS exposure were assessed at baseline, and at 3-, 9-, and 15-months postintervention; home testing occurred at baseline and at 15 months. Stage of action in home testing and in adopting a smoke-free (SF) home policy increased from baseline to 3 months; we observed no further changes in stage of action over time. Airborne nicotine declined from baseline to 15 months (p = .031; n = 9). More research is needed to evaluate interventions to motivate renters and landlords to test and mitigate for radon and adopt SF policies.**

Introduction

Lung cancer is the leading cause of cancer death in the U.S.; an estimated 222,500 new cases and 155,870 deaths were projected in 2017 (National Cancer Institute, n.d.). Smoking is the leading cause of lung cancer, followed by radon (U.S. Department of Health and Human Services [HHS], 2005) and secondhand smoke (SHS) exposure (HHS, 2006). Radon-related lung cancers are more likely in those with a smoking history (National Research Council, 1999).

Environmental risks are inversely related to income (Evans & Kantrowitz, 2002). Nearly one half of those living in multi-unit housing report that SHS enters their living space from elsewhere (Hewett, Sandell, Anderson, & Niebuhr, 2007). Further, socioeconomic status (SES) disparities are associated with lack of action to reduce environmental risks. A family of lower SES is less likely to adopt a smoke-free (SF) home than a family of higher SES (Norman, Ribisl, Howard-Pitney, & Howard, 1999; Wakefield et al., 2000), and a family of lower SES is more likely to live in a rental property.

Landlords often fear that SF policies will hurt their business, expecting higher vacancy, turnover, and tenant complaints (Cramer, Roberts, & Stevens, 2011; Hewett et al., 2007; Snyder, Vick, & King, 2016; Stein et al., 2016). Similarly, lower income individuals (Halpern & Warner, 1994; Hill, Butterfield, & Larsson, 2006; Wang, Ju, Stark, & Teresi, 1999) are least likely to initiate protective radon behaviors. Although radon test kits are relatively inexpensive and are often available for free, primary care providers do not routinely recommend radon testing.

Report-back is a cueing event that might motivate individuals to take action such as adopting a SF home (McBride, Emmons, & Lipkus, 2003; McBride et al., 2008). Report-back is effective in conveying exposure data (Altman et al., 2008), even with low-SES groups, and prompting action to reduce household exposures (Adams et al., 2011). When individuals are provided with evidence of high radon, they are more likely to mitigate (Duckworth, Frank-Stromborg, Oleckno, Duffy, & Burns, 2002; Riesenfeld et al., 2007; Wang et al., 1999).

This exploratory study evaluated the impact, feasibility, and acceptability of a dual home screening and personalized environmental report-back intervention (Hahn et al., 2014) to prompt action to reduce home exposure to radon and SHS in a sample of renters. We hypothesized that, over time, renters who received free in-person home test kits, report-back, and a brief problem-solving intervention would be more ready to take action to reduce radon and SHS exposure, and would have lower radon and SHS levels in their homes.

Methods

Design and Sample

This study was a prospective, quasi-experimental one-group design using quota sampling. Half of eligible renters had at least one smoker living in the home. Participants were eligible to participate if they were at least 21 years, had access to a tele-

phone, had not tested their home for radon within two years, and did not own their home. We recruited participants in primary care clinics at an academic medical center from January–May 2013. Nearly all (97%) eligible renters participated. All 47 participants were assigned to receive the intervention; 23 reported at least one smoker lived in their home. Semistructured interviews were conducted to determine feasibility and acceptability of the intervention.

Intervention

The Freedom from Radon Exposure and Smoking in the Home (FRESH) intervention (Hahn et al., 2014) creates a teachable moment (Lawson & Flocke, 2009; McBride et al., 2003) for lung cancer risk reduction by motivating participants to 1) simultaneously test their homes for radon and SHS (cueing event) and 2) take action by participating in a personalized environmental report-back and brief problem-solving conversation via telephone.

First, we provided free home test kits in person at enrollment, including print and audiovisual instructions on how to deploy and return the kits. Next, if at least one home test value was high, we delivered the personalized intervention (Fiore et al., 2008; Rollnick, Mason, & Butler, 2010) based on stage of readiness to take action (Weinstein & Sandman, 2002) and on observed radon and airborne nicotine values. If radon values were high, we followed the U.S. Environmental Protection Agency (U.S. EPA) radon measurement protocol (U.S. EPA, 2010, 2012) and recommended their landlord contact a certified radon professional for further assessment and mitigation.

If renters provided permission for us to contact their landlord, we offered a voucher covering 30% of the radon mitigation cost, up to $600. If airborne nicotine levels were high, we suggested participants institute and enforce a SF-home policy. If tobacco smokers lived in or visited the home, we provided a brief intervention on quitting (Fiore et al., 2008) and referral to the telephone quit line (1-800-QUIT-NOW). We also provided information to share with their landlords to dispel perceived barriers to adopting a SF-property policy (American Nonsmokers' Rights Foundation, 2014; National Center for Healthy Housing, 2009). If both values were low, we mailed a results letter.

Procedure

Participants completed online or paper and pencil surveys at baseline, and at 3-, 9-, and 15-months postintervention; escalating payments ranged from $10–$40 for completing surveys. Renters were asked to deploy radon and SHS test kits in the home for 6 days at baseline and at 15 months postintervention, and were paid $20 for each pair of returned kits. Unless a participant withdrew, we invited them to complete follow-up surveys and end-of-study home testing even if they had missed prior surveys. All participants were invited to take part in semistructured telephone interviews at end of study.

Measures

Home radon and SHS levels were assessed using short-term radon test kits (Air Chek, Inc.) and passive airborne nicotine samplers (Hammond & Leaderer, 1987; Ogden & Maiolo, 1992). We used the U.S. EPA action level of ≥4.0 pCi/L to determine whether home radon was "high" or "low." Similarly, we used the cutoff of ≥0.1 $\mu g/m^3$ (Eisner, Katz, Yelin, Hammond, & Blanc, 2001; Sockrider, Hudmon, Addy, & Dolan Mullen, 2003) to denote "high" versus "low" air nicotine.

Stage of action between baseline and 3 months postintervention was assessed for home radon testing, home airborne nicotine testing, and adopting a SF-home policy. As the renter does not decide on radon mitigation, stage of action for this outcome was not considered. Stage of action is measured on a continuum of 1) unaware, 2) unengaged, 3) deciding, 4) acting, and 5) maintenance. Stages were assigned at baseline and at each follow-up based on responses to a series of survey items.

The first question was "Have you ever heard about testing your home for radon (testing your home for SHS/adopting a SF-home policy)?" Those who indicated "no" were assigned Stage 1 (unaware). The second question was "Which of the following best describes your thoughts about testing your home for radon (testing your home for SHS/adopting a SF-home policy)?" Response options included: "I've never thought about testing/adopting a SF-home policy," "I'm undecided about testing/adopting a SF-home policy," "I've decided I want to test/adopt a SF-home policy," and "I've decided I do not want to test/adopt a SF-home policy."

Participants who had never thought about home testing or were undecided were assigned Stage 2 (unengaged). Those who had decided for or against the outcome were assigned Stage 3 (deciding). At baseline, Stage 3 (deciding) was the highest available stage of action because radon and SHS testing had not yet occurred and none had tested their homes prior to the study. To measure stage of action for adopting a SF-home policy, we asked, "Have you ever adopted a SF-home policy?" At baseline, participants selecting "yes" were assigned Stage 4 (acting) for adopting a SF-home policy.

The same set of questions and response choices were asked at each follow-up and used to classify stage of action. At 3 months, those who had their homes tested after the baseline survey were considered Stage 4 (acting) for the corresponding outcome(s). These participants had tested their homes at least 6 months prior; therefore they were assigned Stage 5 (maintenance) at 9 and 15 months. For the SF-home policy outcome, participants who had established a SF-home policy at baseline were in Stage 4 (acting) and were assigned Stage 5 (maintenance) for each of the follow-up assessments, assuming the policy was maintained at each. For all others, the same set of criteria was used to define stage of action at each follow-up.

Demographics and personal characteristics were measured via baseline survey including age (in years); gender; race/ethnicity (White/non-Hispanic versus other based on racial/ethnic variability in the accessible population); education (high school or below, some college, college graduate); smoking status (current, former, never); and whether smokers lived in the home. We assessed feasibility and acceptability using a semistructured interview guide to measure motivation to take part in the study and experience with testing and the intervention. If test values were high, we asked whether participants shared the information with their landlord and how the landlord responded.

Data Analysis

Descriptive statistics, including means and standard deviations or frequency distributions, were used to summarize study variables. The Wilcoxon signed-rank test compared radon and airborne nicotine test results from baseline to 15 months. Repeated mea-

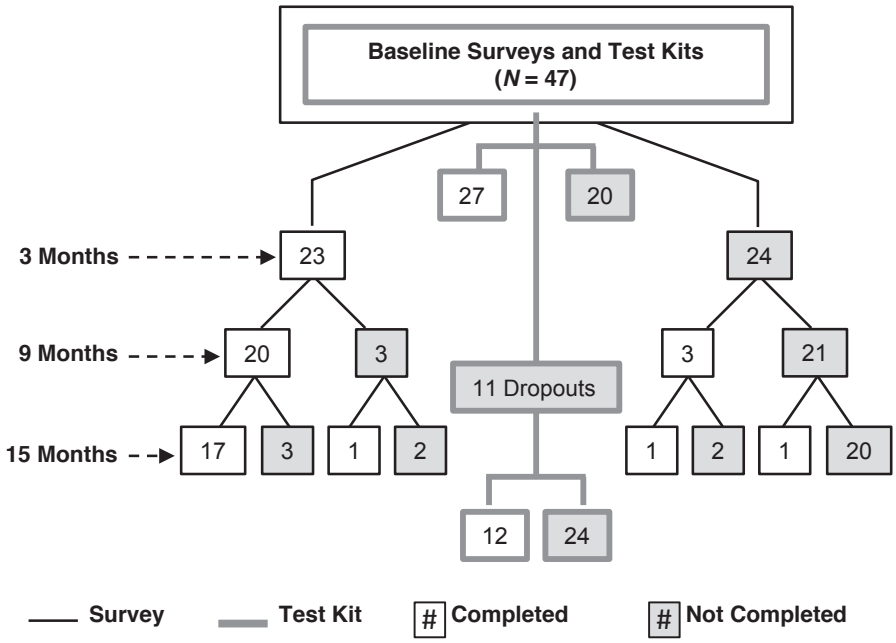
TABLE **1**

Demographic and Personal Characteristics of Participants (*N* = 47)

Characteristic	*n* (%)
Gender	
Male	18 (38.3)
Female	29 (61.7)
Race/ethnicity	
White/non-Hispanic	32 (68.1)
Other	15 (31.9)
Education	
High school or below	14 (29.8)
Some college	17 (36.2)
College graduate	16 (34.0)
Personal smoking status	
Current	17 (37.0)
Former	8 (17.4)
Never	21 (46.6)
Smoker(s) living in the home	
Yes	23 (48.9)
No	24 (51.1)

FIGURE **1**

CONSORT Diagram Detailing Participation in Each Survey and Home Testing (*N* = 47)



CONSORT = Consolidated Standards of Reporting Trials.

sures analysis of variance with Fisher's least significant difference method for pairwise post-hoc comparisons associated stage of action outcomes over time. All data analyses were conducted in SAS version 9.4 and α = .05 was used. We transcribed end-of-study interview data and coded for themes.

Results

The average age of participants was 42.5 years (SD = 14.7) and the majority were female (62%; Table 1). Most were White, non-Hispanic adults with an education level beyond high school who self-identified as never smokers. Consistent with quota sampling, 49% reported one or more smoker(s) living in the home.

The majority (57%) tested their homes for radon and airborne nicotine following the baseline survey (Figure 1). Of those who tested at baseline, over half (52%) had at least one elevated value. Six renters had low radon/high nicotine levels (22%); five had high radon/low nicotine (19%); and one had high radon/high nicotine (4%). Two participants with invalid radon results had high nicotine levels (7%); two others with invalid radon tests had low nicotine (7%). One renter had an unknown airborne nicotine value and had low radon (4%). Ten participants had low radon and low nicotine values (37%). Based on at least one elevated test, 14 renters qualified for the intervention; we delivered 12 interventions total.

Each stage of action outcomes (i.e., radon testing, airborne nicotine testing, and instituting a SF-home policy) exhibited an increase from baseline to 3 months postintervention, followed by a relatively stable value at each follow-up (Figure 2). For each outcome, the main effect of time was significant, with $F > 16.3$ and $p < .001$ in each of the three models. The post-hoc pairwise comparisons were nearly identical for the three models: for each stage of action outcome, the baseline stage was significantly lower than each of the three follow-up assessments ($p < .001$ for each comparison), while the three postintervention assessments did not differ from each other for any of the outcomes ($p > .07$ for each of these comparisons).

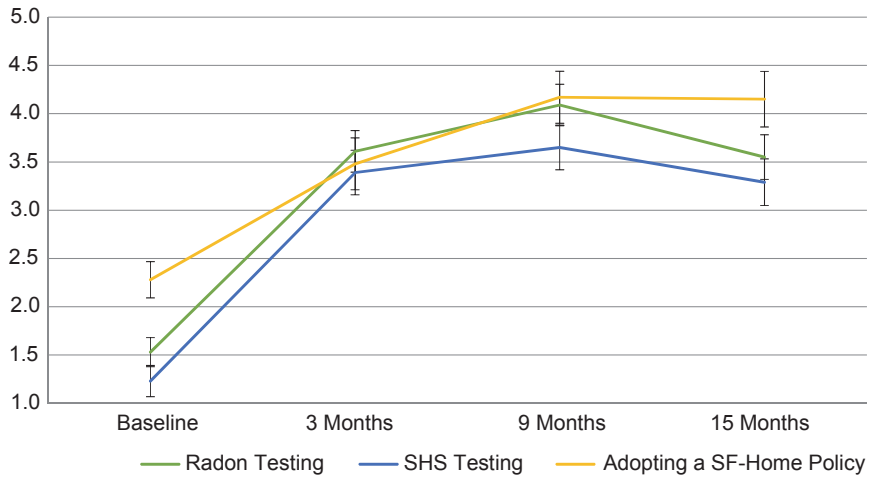
Among those who tested for radon at baseline and at 15 months, there was no difference in observed values between these two assessments ($p = .16$ for the signed-rank test, with 10 renters testing both times). Among those who tested for airborne nicotine at both time points, there was a significant decline in airborne nicotine ($p = .031$ for the signed-rank test; $n = 9$).

Participants also reported risk reduction outcomes at follow-up. One half of renters without a SF-home policy at baseline adopted a more restrictive or comprehensive SF-home policy by 3 months. From baseline to 3 months, one of the 17 smokers quit smoking. Six of the 21 participants who completed the 15-month survey said they wanted to mitigate for radon, but only two had high radon at baseline (the only test available at the 15-month survey). These two renters had talked to their landlord about their rental home's radon level, but their radon level remained high at 15 months.

Home testing completion and retention were challenges with this hard-to-reach

FIGURE **2**

Average Stage of Action Outcomes Over Time With Standard Error Bars (*N* = 47)



SHS = secondhand smoke; SF = smoke-free.

population (Figure 1). At baseline, 57% completed at least one radon and/or airborne nicotine test. Survey participation at 3 months was 49%. Between 3–9 months, three participants were lost to follow-up, and participation rates at 9 and 15 months were 52% and 49%, respectively, of those remaining in the study. By the 15-month survey, 11 participants were not invited to test their homes because they were either lost to follow-up (*n* = 3), had moved after baseline testing (*n* = 6), or had become homeowners (*n* = 2). Of the 36 who were invited to retest at 15 months, 10 completed radon and airborne nicotine testing (28%).

Renters shared at end of study (*n* = 21) that they liked the FRESH intervention. Renters liked home testing the most: kits were free and easy to deploy and they appreciated getting the results with corresponding health information. Some renters expected landlords to be unsupportive (e.g., would not fix high radon due to cost) and they expressed fear (e.g., having to move). Renters suggested that if we engaged the landlords earlier (i.e., before home testing), they might have perceived the landlord as more supportive. Renters advised that we ask landlords to distribute study recruitment fliers in future studies.

Discussion

As hypothesized, study participants were more ready to take action to test their homes for radon and SHS and institute a SF-home policy 3 months after the FRESH intervention. Half of those who did not have a SF-home policy at baseline adopted one 3 months after the intervention.

Similarly, airborne nicotine levels declined significantly by 15 months postintervention among those who tested at end of study. Providing environmental report-back and brief problem-solving skills in the primary care setting might reduce SHS exposure in this vulnerable population. SHS education and SF-home policies are not routinely recommended by primary care providers, however, as these recommendations are omitted from the Guide to Clinical Preventive Services (Agency for Healthcare Research and Quality, 2008).

Similarly, radon testing is missing from the Guide. Further, only the state of Maine requires landlords to test and disclose radon levels to their tenants (Larsson, 2014). Changes to state and federal policy and the clinical practice guideline, as well as further research to test environmental report-back interventions in primary care settings, are warranted.

Further, research engaging landlords might yield even more powerful results. Landlords with SF policies in multi-unit housing are less likely to report vacancies (11% versus 54%) and turnover (4% versus 50%; *p* = .0001) compared with their counterparts without these policies (Cramer et al., 2011; Hewett et al., 2007; Snyder et al., 2016; Stein et al., 2016). Studies on SF policy with landlords, however, have been cross-sectional and descriptive; few studies test environmental risk reduction interventions with landlords.

Our hypothesis that radon exposure would decline by end of study was not supported. Radon levels at 15 months after the intervention remained unchanged. Only two participants whose rental homes tested high for radon talked with their landlord, and none of the landlords redeemed the monetary voucher. Proper mitigation systems are expensive to install, and low-SES populations often cannot afford mitigation.

Mitigation costs range from $1,250–$1,750 for an average home on a basement, and up to $2,500–$3,000 for a home on a crawlspace. Costs are higher for multi-unit housing. Lack of knowledge and perceived risk from radon exposure are additional barriers to radon mitigation. One study with low-income rural residents reported low correlations between actual radon risk (as defined by a radon test result) and perceived risk, with only 20% of respondents correctly understanding their risk status (Hill et al., 2006). Engaging landlords to assist with renter recruitment and as research participants might increase likelihood of radon mitigation. Further, community resources and tax credits might help promote radon mitigation with property owners.

The FRESH intervention was feasible in that nearly 6 in 10 renters tested their homes for radon and SHS when provided with free home test kits in the primary care setting. Compared with a pilot study of homeowners in a pediatric clinic, home testing rates in this sample of renters were lower for radon (57% versus 76%) but higher for airborne nicotine (57% versus 48%) (Hahn et al., 2014). Homeowners in the earlier study were not paid to test their homes.

Interestingly, we noted lower participation when inviting renters to test again at 15 months. Only about one fourth of those who were sent free radon and airborne nicotine kits actually tested at 15 months. The

low testing rate at end of study might have been related to the fact that nearly 4 in 10 who tested at baseline had low radon and low airborne nicotine results and might not have been motivated to test again. In fact, only 20% of those who were low/low at baseline retested at 15 months, compared with 43% of those with elevated tests. Albeit not significant, this finding indicates a trend toward lower likelihood of testing at end of study with low/low results at baseline.

Recruiting and retaining renters in research studies is a challenge, and the feasibility of delivering FRESH with renters might require different strategies. By their nature, renters are transient and their daily lives may be insecure and chaotic. Further, because they do not own their homes, renters have limited control over home exposure to environmental contaminants (Larsson, 2014). The fact that the majority tested their homes for radon and SHS at baseline is promising. Attrition rates were extraordinarily high, however, with only half completing follow-up surveys. Although there were relatively high exposure levels in this sample at baseline (26%, high radon; 35% high airborne nicotine), existing programs do not reach this vulnerable and hard-to-reach population. There is very little radon testing in rental property, but this exploratory study shows there is interest in testing among renters despite challenges with study retention.

Regardless of feasibility challenges, the FRESH intervention was acceptable to the renters and they liked testing and getting their data back. When individuals are provided with evidence of high radon, they are more likely to mitigate (Duckworth et al., 2002; Riesenfeld et al., 2007; Wang et al., 1999). Renters in our study, however, were skeptical that their landlords would fix the problem and some expressed fear in sharing results with their landlords. If landlords had access to affordable remediation resources for their rental property, they might be less concerned about vacancy and tenant turnover (Cramer et al., 2011; Hewett et al., 2007) and more likely to support healthy homes. Recruiting landlords, along with renters, and delivering FRESH with both groups might prompt action to reduce radon and SHS exposure.

The primary limitation of this exploratory study is the small sample size and lack of a control group. These preliminary findings, and in particular the elevated rate of radon and SHS exposure, underscore the need for increased attention to the environmental impact of radon and SHS on this vulnerable population. An additional limitation was that because participants had not previously tested for radon and SHS in their homes, the stage of action for testing was constrained to "deciding" or below, limiting the range of possible action levels at baseline. Finally, there was high attrition in this transient population.

Conclusion

Given that the combination of first and secondhand smoke and radon exposure increases lung cancer risk nearly tenfold (U.S. EPA, 2012), there is a critical need for effective interventions to reduce these environmental risks and prevent lung cancer among the most vulnerable (DeLancey, Thun, Jemal, & Ward, 2008; Ward et al., 2004), including renters who are disproportionately low income. FRESH is a feasible and acceptable personalized report-back intervention that shows promise in reducing inequities in environmentally induced diseases such as lung cancer. Unfortunately, the environmental risks that exist in the home, and particularly in rental property, are not readily acknowledged by those at risk and those who can provide solutions.

Changes to policy and clinical practice are needed to promote radon testing and mitigation, as well as SF environments to reduce lung cancer risk. Future research needs to develop and test strategies to inspire landlords, to consider environmental risk reduction as a way to promote healthy homes and attract future tenants (Cramer et al., 2011; Hewett et al., 2007).

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Corresponding Author: Ellen J. Hahn, Professor and Director, BREATHE, University of Kentucky College of Nursing, 2265 Harrodsburg Road, Suite 202, Lexington, KY 40504. E-mail: ejhahn00@email.uky.edu.

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Did You Know?

Several of NEHA's food safety trainings and credential preparedness courses are available online. The Professional Food Manager, Professional Food Handler, Certified Professional–Food Safety, and a multitude of HACCP courses can all be taken at your own pace from the comfort of your office or home. Visit www.neha.org/store to learn more about NEHA's online courses.