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Short communication

Short Communication: Radon testing via a state tobacco quitline

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ABSTRACT

Objective: Exposure to radon gas at home is the second largest cause of lung cancer after smoking and dramatically increases smokers' risk of lung cancer. State tobacco quitlines are uniquely positioned to inform smokers about radon, yet, to our knowledge, none does so. We explored the feasibility of introducing free radon tests via the tobacco quitline in North Dakota, a state with one of the highest radon levels in the U.S.

Methods: Five hundred consecutive callers to the ND Quits Tobacco quitline from February 2021 to February 2023 were invited to complete a brief radon questionnaire and receive a free radon test kit. Radon tests were barcoded so that the return rate of the tests and the radon levels could be determined.

Results: Two hundred fifty-one (51 %) callers completed the questionnaire and seventy-five radon tests were successfully returned to the laboratory. More than one third of the test results were $\geq$ 4.0 pCi/L, the action level recommended by the EPA. Only 1 in 5 participants reported knowing that radon caused lung cancer.

Conclusion: Radon knowledge among ND smokers is poor. Radon test distribution via quitlines is feasible and may be a valuable addition to quitline services, particularly in states with high radon levels.

1. Introduction

The enormous societal costs incurred by cigarette smoking have led to various government-sponsored efforts to promote smoking cessation. One of the best-known of these, telephone quitlines, offer callers a menu of services, ranging from counseling and support groups to medicines that reduce craving for nicotine. California established the first publicly-funded U.S. quitline in 1992. Quitlines now exist in every U.S. state and territory and in all Canadian provinces and territories, as well as in many other countries (Anderson and Zhu, 2007).

Although the causal role of smoking in lung cancer is well known, another cause of lung cancer, radon, is less well known. Radon is a radioactive gas produced by the natural decay of radioactive elements present in rocks and soils. Radon's role in lung cancer is poorly understood by the public, in part, because radon is invisible, tasteless, and odorless and because its detection requires a specialized test (Vogeltanz-Holm and Schwartz, 2018). Radon seeps into homes via cracks in the foundation and can accumulate indoors, especially in lower levels of homes and during cold weather, when homes are tightly sealed. Radon undergoes further radioactive decay and emits high-energy alpha (α) particles. If these particles are inhaled, they can damage the DNA of respiratory cells and cause lung cancer. Radon accounts for 21,000 lung cancer deaths per year and is the second leading cause of lung cancer after smoking (EPA).

Radon greatly magnifies the carcinogenicity of smoking. For example, smokers exposed to high levels of radon increase their risk of lung cancer 10 times (Lantz et al., 2013). This suggests that individuals who want to quit smoking also may want to reduce their radon exposure. To our knowledge, no quitline presently informs callers about radon or how to test their home (Sheffer, 2022). We explored the feasibility of offering free radon tests to callers to the quitline in North Dakota (ND), a state with one of the highest radon levels in the U.S. (Schwartz and Klug, 2016).

2. Methods

ND Quits is a quitline for North Dakotans seeking assistance in quitting smoking or using smokeless tobacco. It is funded by the ND Department of Health & Human Services and administered by the University of ND School of Medicine & Health Sciences in Grand Forks, ND.

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Despite ND's high radon levels (e.g., the average radon in homes in Grand Forks is 11.7 pCi/L, 9 times the U.S. average), ND has no laws requiring radon testing or disclosure (North Dakota Department of Health and Human Services, 1988; Temple University, 2022).

Beginning in 2/2021, counsellors for ND Quits read the following to new callers:

> "*We have received grant funding to bring you information on testing for radon gas in your home, including an opportunity for you to receive a free test kit. Radon is a naturally occurring gas present in high concentration in some homes in ND. Radon can be the cause of cancer and this risk is even higher in people who smoke. Because radon has no odor or color, it cannot be detected without using a test kit that can be mailed to a testing center to receive a result. Radon levels can be reduced and the associated risk lowered by relatively simple measures to bring fresh air into the home and radon out of the home.*"

Callers were asked if they wanted to test their home, and if so, they completed a questionnaire about their age, race, and zip code, as well as about home ownership, home characteristics, and smoking history. Behavioral questions included smoking history and basement use (where radon levels are known to be highest). Callers also were questioned about their radon knowledge. Callers who completed the questionnaire received a return postage-paid radon test kit in the mail. The test kits were EPA-approved, 48–96 h (short-term) charcoal tests (Alpha Energy Labs, TX). The test kits were bar-coded so that we could identify those that were returned to the laboratory.

The laboratory sent the test results to each test user. The radon levels and the self-reported characteristics of the testers' homes (number of floors, presence of a basement) were reported to the investigators, but in order to ensure callers' anonymity, the testers' addresses were not. Similarly, the questionnaire data could not be linked to individual testers. (For the instructions that accompanied the test, and a sample test result form, see Alpha Energy Laboratories (2024A and 2024B), respectively).

Data were analyzed by descriptive statistics. Differences in radon levels by location within the home were analyzed by independent t-tests. This research was approved by the University of ND School of Medicine Institutional Review Board, # IRB 202009-041.

3. Results

Five hundred callers from 45 of ND'S 53 counties utilized the ND Quitline from 2/2021–2/2023. Two hundred fifty-one callers (51 %) completed the questionnaire and received a radon test kit. The majority of callers (91 %) were White. Their average age was 53.6 (SD 14.4) and there were slightly more females than males (see Fig. 1). Eighty-nine % began smoking as children and 84 % reported smoking between 1 and 2 packs of cigarettes/day (see Fig. 2). Twenty-two % reported that they knew that radon caused lung cancer and 7 % reported that they learned about radon from their health care provider.

Of the 251 test kits mailed to callers, 75 (30 %) were returned to the testing laboratory. The measured radon levels ranged from 0.5 to 35.5 pCi/L, with a mean of 4.9 pCi/L (SD 5.87) and a median of 2.9 pCi/L. Thirty four % of the test results were $\geq$ 4.0 pCi/L (i.e., the action level for remediation recommended by the EPA). As expected, basement radon levels were significantly higher than levels on other floors ($P < .001$). Homes with basements were significantly more likely to have high radon levels on the first floor than homes without basements.

4. Discussion

The primary goal of this study was to explore the feasibility of offering free radon test kits to smokers who called the ND Quits Tobacco quitline. A secondary goal was to measure radon knowledge and behaviors among callers. We gauged feasibility by the test request rate and test-completion rate (the percentage of tests returned to the lab). More

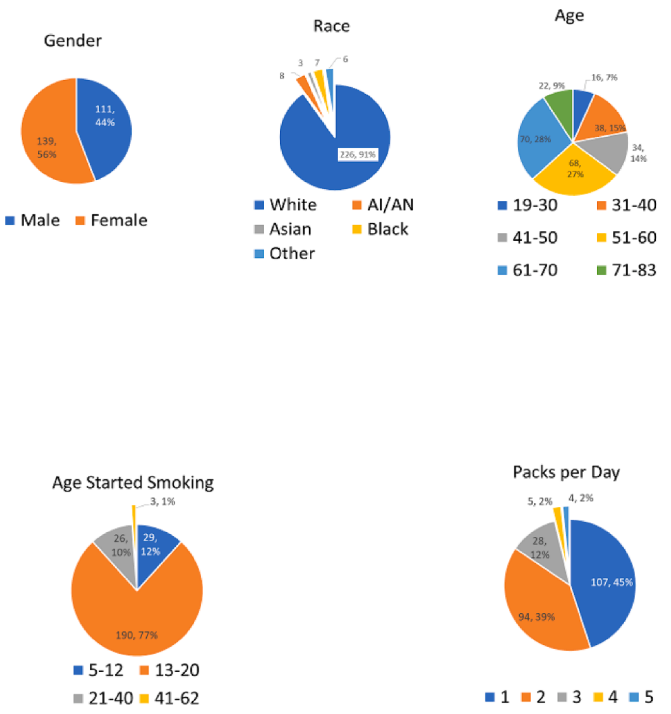

Fig. 1. Descriptive characteristics of the first 500 callers to the North Dakota Quitline from February 2021 to February 2023.

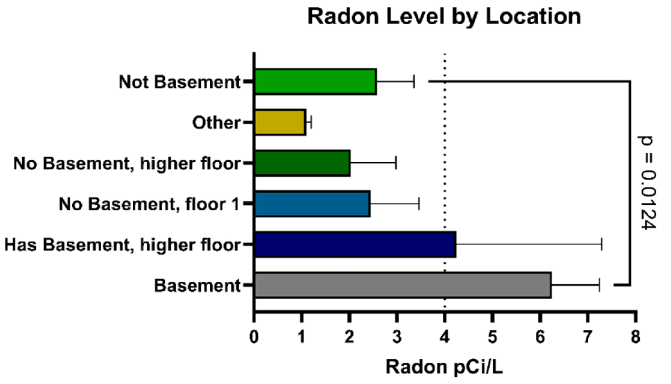

Fig. 2. Radon levels by floor in the homes of callers to the North Dakota Quitline, February 2021 to February 2023.

than 50 % of callers requested a test and 30 % of the tests were returned to the laboratory. Our test completion rate compares favorably to values reported in the literature. For example, in a study of >2,300 individuals, Cholowsky et al. (2021) reported that after a single encounter with radon awareness information, 20 % completed a radon test. We note that, although it was not the focus of this study, offering radon tests via quitlines also may be feasible economically, as the cost of single-use radon tests (purchased in bulk) was approximately $9 per test. This is considerably less expensive than many items, e.g., prescription medicines, that are commonly distributed by U.S. quitlines.

The vast majority of callers to the ND quitline, 89 %, began smoking as children. This is concerning given that early age at smoking initiation increases the risk of lung cancer (Hymowitz, 2012). Moreover, due to the shape of their lungs and children's higher respiratory rate, the risk of lung cancer to children from radon exposure is twice that of adults. For children exposed to both cigarette smoke and radon, the lung cancer risk is at least 20 times greater than for adults (Agency for Toxic Substances and Disease Registry).

Radon knowledge among quitline callers was low. Although

approximately half of the respondents reported that they knew that they should test for radon, they appeared not to know why; only 22 % knew that radon caused lung cancer. Seven (7) % of respondents reported that they learned about radon from their health care provider. This value is consistent with findings from our recent survey of family physicians in ND, 80 % of whom reported never discussing the combined effects of radon and cigarettes with patients (Schmitz et al., 2021). The low level of radon knowledge among smokers indicates that novel venues for radon education, e.g., quitlines, are needed for this population.

Radon levels in the homes of callers varied from 0.5 to 35.5 pCi/L. More than 1/3 of the values were ≥ 4pCi/L, the EPA reference level for remediation. This is important because, relative to the average radon level in U.S. homes (1.3 pCi/L), a radon level of 4 pCi/L (found in 63 % of a population-based sample of homes in ND [N = 1.596]) increases the risk of lung cancer among smokers >3 times; this increases to 10 times for smokers exposed to radon at 20 pCi/L (North Dakota Department of Health and Human Services, 1988; EPA, 2022) Thus, elevated radon levels are common in the homes of ND smokers, the majority of whom are unaware that radon greatly increases their lung cancer risk.

Our study has several limitations. First, due to coding practices that preserved caller anonymity, we were unable to compare characteristics of individuals who utilized the radon test vs. individuals who did not. Second, we used short-term radon tests that measure radon over a time window of 48–96 h. Short-term tests have been considered less accurate than longer-term tests, whose radon values are integrated over several months (Schwartz et al., 2022). However, a comparison of a national dataset of 2,245 pairs of collocated short- and long-term radon tests indicate that the short-term tests explained nearly 80 % of the variance in seasonally-adjusted long-term tests (Li et al., 2023). Third, individuals who call the quitline are highly motivated to quit smoking. Although this is clearly an advantage in terms of accessing individuals who are ready to change their behavior, it is a subset of the at-risk population of smokers.

Conversely, our pilot study has several strengths: it was conducted in a high-radon state; the setting was population-based, and we studied a relatively large sample of sequential callers (N = 500). Thus, it likely represents an unbiased sample of ND quitline callers. We observed a relatively high radon test return rate, 30 %. The act of completing the brief radon survey itself may have promoted callers to use and return the test. This suggests that quitlines that offer radon tests include a brief survey to prompt radon testing. Importantly, this is the first study to demonstrate that distributing radon tests via quitlines is feasible. In an unpublished study (reported online), Larrson attempted to introduce radon testing via the quitline in Montana. Six hundred (600) callers were invited to participate. Fourteen (14) individuals (2.3 %) accepted the invitation and only 2 returned the test to the laboratory (Larsson, 2023). It is likely that the > 50 % participation rate we observed reflects that the facts that, unlike Larrson's protocol, in which callers were invited to receive a radon test *by mail, after they had enrolled* in the quitline, we invited participants via telephone, simultaneous with quitline enrollment.

In summary, in our pilot study of 500 callers to the ND Quits Tobacco quitline, approximately 50 % of callers requested a radon test and nearly 1/3 returned the tests to the laboratory. Only 1 in 5 callers knew that radon caused lung cancer. We conclude that distributing radon tests via tobacco quitlines is feasible and may be a valuable addition to quitline services, particularly in states with high radon levels.

CRediT authorship contribution statement

David Schmitz: Writing – review & editing, Methodology, Funding acquisition, Conceptualization. **Marilyn G. Klug:** Writing – review & editing, Methodology, Formal analysis, Data curation. **Gary G. Schwartz:** Writing – review & editing, Writing – original draft, Resources, Funding acquisition, Conceptualization.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Data availability

The data used are confidential.

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