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Radon Awareness and Policy Perspectives on Testing and Mitigation

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Abstract: One in three homes in Utah (USA) contains dangerous levels of radon. Except for a radon mitigation certification law, Utah's radon laws are nonexistent. To determine public perception of state policies on radon testing and mitigation, a social cognitive theory-based 52-item questionnaire was administered to residents (N = 307) who visited the Utah County Health Department (UCHD) during the study period. Respondents were divided into an Environmental Health Group (n = 110), who purchased a radon kit, and Vital Records Control Group (n = 197), who filed/obtained birth/death certificates at UCHD. Ninety percent responded they had never tested their homes for radon, and 99% were not aware of state policies regarding radon. Support for various radon policies was significantly associated with older age (odds ratios (OR): 0.37–0.52), being female (OR: 2.60–7.79), lower annual family income (OR: 2.27), and theoretical constructs of behavioral modeling (OR: 2.31–2.55) and risk perception (OR: 2.55–3.71). To increase awareness, testing, and remediation, respondents suggested increasing public education/awareness, requiring testing in homes, businesses, and public buildings, and increasing access to testing. Multi-sectoral radon risk reduction programs could incorporate behavioral modeling and risk perception as components to create a radon testing and mitigation culture in Utah.

Keywords: radon policy; radon testing; policy perspectives; radon in homes

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1. Introduction

1.1. High Residential Radon Exposure in Utah Homes

Utah has a high residential radon exposure. One third of homes in Utah have radon levels greater than 4.0 picoCuries per liter of air (pCi/L) [1], which is five times the national radon exposure rate of one in 15 homes [2–4]. Levels of 4.0 pCi/L or higher pose a danger to a family's health and require remediation to reduce residential radon exposure [1–4]. Among Utah homes tested for radon, the average indoor level registers at 5.3 pCi/L [5], whereas nationally, America's homes average at 1.3 pCi/L [2,6].

Radon is a radioactive gas. It is colorless, odorless, tasteless, and invisible. It is produced by the natural breakdown of uranium into thorium and radium in the soil, rock, and water [7]. Any level of exposure carries a health risk. Ambient air typically contains 0.4 pCi/L of radon, but this rarely reaches significant levels because of the dilution and dispersal in the environment [2,6]. The United States (U.S.) Environmental Protection Agency (EPA) considers 4.0 pCi/L or higher as the level that requires corrective action. However, since there is no known safe threshold for indoor radon concentration, the EPA recommends mitigating homes even at levels between 2.0 and 4.0 pCi/L [2,6].

Exposure to radon occurs mainly by inhalation. As a gas, it can diffuse through cracks, crevices, cavities, or pores in the foundation floor, junctions between floors and walls, and in gaps around pipes [2,8]. Given its density and proximity to the underground soil source, radon tends to accumulate in enclosed environments, particularly in basements,

cellars, and crawl spaces. Radon can also dissolve in ground water [2,9,10], which can then find its way into drinking water if the household water source comes from wells, springs, or boreholes [2,8–10]. However, natural emission from the soil beneath a home's foundation remains the largest source of indoor radon. An air pressure within the house that is lower than in the surrounding soil facilitates the diffusion and build-up of radon inside the house. Since only one to two percent of radon comes from drinking water [9,10], inhaled radon presents the greater risk for lung cancer [2,3,9,10]. Nevertheless, exposure over time to radon from indoor air and/or household water carries a risk for cancer. Radon in drinking water has been shown to increase the risk for gastrointestinal cancers, primarily the stomach, but it can also involve the liver, kidneys, or ureters [9–12]. According to the Centers for Disease Control and Prevention (CDC), radon in water accounts for 30 to 1800 deaths annually [9].

Radon is a Group 1 carcinogen [8,13,14]. This means that there is strong evidence that it causes cancer among humans. Radon was classified as a carcinogen in 2009 by the International Agency for Research on Cancer (IARC) [13]. Leading health organizations, such as the CDC, American Lung Association (ALA), American Medical Association (AMA), and the American Public Health Association (APHA), echo the risk for lung cancer presented by exposure to radon [15]. Residential radon causes lung cancer in both smokers and non-smokers and requires testing to accurately assess exposure [16]. Among non-smokers, radon is the leading cause of lung cancer. Among smokers, radon is the second most common cause of lung cancer next to smoking and followed by second-hand smoke [1–4]. Based on the National Academy of Sciences' (NAS) Biological Effects of Ionizing Radiation (BEIR) VI Report and the recommendations from the Science Advisory Board (SAB), the EPA calculates that 21,000 annual deaths from lung cancer are attributable to radon exposure. Worldwide, the World Health Organization (WHO) estimates that 3% to 14% of the total cases of lung cancer in a country are attributable to radon, with the actual levels dependent on the national prevalence of smoking and average radon exposure [8].

Radon exacerbates the chemical damage in the lungs caused by smoking. WHO estimates that the risk for radon-induced lung cancer is 25 times higher in smokers than non-smokers [8]. As radon and its decay products are inhaled, they are deposited in the alveolar cells of the lungs. Radon in the lungs undergoes radioactive decay and is transformed into radon daughters or radon progenies, such as polonium-218, polonium-214, and lead-214, which emit ionizing radiation in the form of alpha, beta, and gamma particles [13,14,17,18]. Alpha radiation is comprised of highly charged radioactive particles that cause extensive cellular and DNA damage [13,14,17,18]. Such damage stimulates further cellular response in the form of cell lysis and transformation, chromosomal and genetic abnormalities, and mutations, with various biological responses in adjacent cells that amplify the effects of the original damage, which eventually lead to carcinogenesis [13,14,17,18]. The synergistic relationship between smoking and radon is evidenced by the estimates of lung cancer cases among smokers and non-smokers [8]. Based on the U.S. EPA analysis, a 2.0 pCi/L radon exposure over a lifetime translates to 32 people developing lung cancer out of 1000 smokers, compared to 4 people out of 1000 never-smokers [2,3]. A 4.0 pCi/L radon exposure over a lifetime translates to 62 people developing lung cancer out of 1000 smokers, compared to 7 people out of 1000 never-smokers [2,3]. Using individual data from 13 case-control studies from nine European countries, Darby et al. determined the association between home exposure to radon and lung cancer risk. Individuals in the study lived in their homes from 5 to 34 years. The mean indoor radon concentration in the control group was 97 Bq/m^3 (2.6 pCi/L) but averaged 104 Bq/m^3 (2.8 pCi/L) in the lung cancer group. Darby et al. found that home exposure from radon progenies carried an elevated risk for lung cancer, particularly for smokers. Cigarette smokers have 25 times higher absolute risk for lung cancer at 10%, 12%, and 16%, even at radon concentrations of 0, 100, and 400 Bq/m^3, which corresponded to 0, 2.7, 10.8 pCi/m^3 [19].

The risk for radon-induced lung cancer depends on the indoor levels of radon, duration of exposure, and smoking history. As Americans spend almost 95% of their time

indoors, even before the COVID-19 pandemic lockdowns and quarantines, chronic radon exposure poses a significant health risk [2,3]. Given the chemical properties of radon, people can continue to live and work in their homes and yet remain unsuspecting of the elevated radon levels to which they are exposed. Unless indoor air is tested, people remain unaware of the levels of radon in their homes.

1.2. Utah's Landscape as a Geological Hazard

Utah is the 13th largest state in the U.S. with an area of 84,916 square miles [20]. The whole state is bordered by the Rocky Mountains with the Wasatch Range on the west side and the Uinta Range on the east [20]. Utah's location between several mountain states has earned itself the title of "Crossroads of the West" [20]. Comprised of valleys, plateaus, and mountains, Utah is home to "five national parks, six national monuments, a national recreation area, and several state parks" [20] (paragraph 6). The magnificence of Utah's diverse physical landscape is the product of its geological process and rich mineral deposits. It contains one of the world's largest deposits of hydrocarbons that include "coal, oil, oil shale, tar sands, gilsonite, and natural gas" [20] (paragraph 6). These energy resources, including deposits of uranium, are concentrated in Utah's central and eastern counties [21].

Radon is found across the U.S. [2]. The Rocky Mountain states, which includes Utah, are among those with the highest levels of radon. Utah's geological landscape is rich in uranium deposits, rendering the whole state vulnerable to indoor radon exposure. Radon, a naturally occurring carcinogen, is a byproduct of the radioactive decay of uranium and thorium deposits that are naturally found in rocks, soil, and water [2,6,7,17]. Uranium-238 spontaneously transforms into radium-226 with a half-life of 1600 years, which in turn transforms into the most common radon isotope, radon-222, a gas with a half-life of 3.8 days [18]. As uranium decays into radionuclides of radium and radon, alpha, beta, and gamma radiation are released. Alpha radiation, in particular, can cause extensive damage to cells and DNA [7,17,18].

Inhaled radon comes mainly from the soil. Thus, an area's geological landscape serves as an important predictor of indoor radon levels. In 1993, the EPA created a map of radon zones by county across the U.S. to determine areas with potential high indoor radon levels based on indoor tests, geology, aerial radioactivity, soil, and foundation [22]. An interactive version with each state's radon information and state-designated contact is available at the EPA website [22]. This map serves as a guide for implementing radon-resistant building codes and for supplementing locally available data on indoor radon levels.

The EPA geospatially quantifies the predicted average indoor radon exposure into three zones. U.S. counties under Zone 1 have the highest predicted average indoor radon levels at greater than 4.0 pCi/L. Seven of Utah's counties, located in the central and eastern parts of the state where uranium deposits are high, are designated under Zone 1: Piute; Sevier; Sanpete; Carbon; Grand; Duchesne; and Uintah [22]. U.S. Counties under Zone 2 have predicted indoor radon levels between 2.0–4.0 pCi/L. Utah's 22 remaining counties are classified as Zone 2 areas [22]. Thus, the whole State of Utah would likely necessitate radon reduction measures to reach acceptable levels. Zone 3 counties have the lowest predicted indoor radon readings at lower than 2.0 pCi/L [22].

1.3. Radon Levels in Utah County

Utah County is the second most populated county in Utah next to Salt Lake County and followed by Davis County. It is a little over 2000 square miles in size with a 2019 population of 636,235 [23]. Close to 93% of residents identify as white [23]. Based on other 2019 statistics, out of the 186,554 housing units in the county, close to 68% were occupied by homeowners, the median home value was about USD 306,000, the median household income was almost USD 75,000, and about four people lived in each household [23]. The median gross rent in 2019 was a little over USD 1000 [23]. Among residents who were 25 years or older, close to 95% were at least high school graduates, while about 41% were college graduates or had received higher education [23].

Utah County is classified by the EPA under Zone 2 [22]. Based on the 2019 short-term test results by county and zip code that were compiled by the Utah Department of Environmental Quality, the average levels of indoor radon in Utah County spanned a range of 0.9 pCi/L to a high of 7.6 pCi/L, compared to the county's average of 4.7 pCi/L and the state's average of 4.9 pCi/L [24]. The reading of 7.6 pCi/L in Utah County was mainly in the 84602-zip code in the City of Provo, with a 7.1 pCi/L reading for the 84655-zip code that includes the towns of Santaquin, Genola, and Elberta [24]. The 0.9 pCi/L level was in the 84633-zip code in the town of Goshen, 28 miles south of Provo, and five to seven miles west of Santaquin, Genola, and Elberta [24]. Although these areas are designated under the EPA Zone 2, their 2019 short-term tests registered at levels that would have otherwise classified them under Zone 1.

1.4. Radon Testing and Mitigation

The EPA recommends that all homes need to be tested for radon regardless of geographical location, age, or type of foundation [2]. Testing can also be done in any indoor facility such as schools, offices, businesses, and commercial buildings. Mitigation is necessary at radon levels of 4.0 pCi/L or higher and is recommended if radon levels are between 2.0 and 4.0 pCi/L [2,16]. Homes within the same vicinity may have different radon levels. It is not unusual for certain homes to contain excessive amounts of radon when others do not.

Testing is easy, quick, and inexpensive. An individual homeowner or a certified radon professional can conduct the test. Radon tests kits can be purchased online, from hardware or home improvement stores, or from the local county health department [1,2,16]. The test kit with a detector is typically placed in the basement, or in the lowest occupied level of the home, where airflow is minimal, and is placed at least 20 inches from the floor in an undisturbed area far from drafts, heat, humidity, and exterior walls. To ensure accuracy in measurement, windows and doors must be kept closed for twelve hours before the test and throughout the duration of the test [2]. Heating or air-conditioning units may be kept on as these systems are only re-circulating indoor air [2]. Once testing is completed, the kit is resealed and sent to the lab for analysis [2,16].

There are two available tests for radon, a short-term and a long-term test. Short-term tests are performed anywhere between two to 90 days [2,16,25], while long-term tests are carried out for more than 90 days or for as long as 12 months, usually after the first short-term test showed borderline or high levels of radon [2,16,26].

A short-term test is often used to initially assess the levels of indoor radon. It should not be carried out during high winds or storms as this could cause radon to diffuse outside and result in erroneously low levels during the short testing period [2]. Short-term tests can utilize a charcoal canister, alpha track, electric ion chamber, continuous monitor, or a charcoal liquid scintillation detector [2,16]. An activated charcoal radon sampler short-term test is typically priced at USD 16 to USD 36 and is available at a discounted cost of USD 11.00 for Utah residents, including the lab analysis [25]. It is placed in the test site for two to four days or for 48 to 96 h [25].

There is continuous radioactive decay of uranium, thorium, and radium in the rocks and soil underneath the foundation that can increase indoor radon concentrations. Thus, testing needs to be repeated every two years, even after a previous low reading, to determine if the indoor radon is increasing to dangerous levels [2]. Testing can also be repeated when a basement is being converted or remodeled into a home office or bedroom [2,16].

Initial results at 4.0 pCi/L or higher require re-testing to determine accuracy [2,16]. A second short-term test or a long-term test can be used. A long-term test can either use an alpha track or an electric detector [2]. A long-term test kit using an alpha track radon detector costs around USD 31, but is available to Utah residents at a discounted price of USD 29.00, including the cost of a lab analysis [26]. This particular kit is run for several months (91 to 365 days) to determine the average radon levels in a year or over a prolonged period of time.

Initial readings registering at 8.0 pCi/L or higher require another short-term test [2]. If the readings continue to be at 4.0 pCi/L or higher after the follow-up test, mitigation is necessary to reduce health risks [2,16]. A homeowner may carry out the recommended remediation action or hire a licensed mitigator to do so and to identify structural issues that allow radon to leak indoors [2]. Mitigation methods may include soil depressurization, ventilation, surface sealing, and others [2].

For the homebuyer or future homeowner, homes can be built with radon-resistant features to reduce the entry of radon in the home and/or to vent it outside. Installing such features during the construction process is more cost-effective compared to retrofitting the home after it is built. Typical radon-reduction techniques include (1) installing a 4-inch layer of coarse gravel below the foundation to allow soil gases, including radon, to diffuse; (2) placing a vertical 3- or 4-inch solid polyvinyl chloride Schedule 40 pipe from the gravel below the house to divert radon and other soil gases outside; (3) using a heavy-duty plastic sheet or vapor retarder above the gravel layer to prevent the entry of radon inside the house; and (4) sealing and caulking cracks and crevices in the foundation slab and in the walls to reduce radon infiltration and accumulation indoors [2,8,27]. Another preventive construction feature involves installing an electrical junction box or outlet in the attic that can be used with a vent fan should radon levels increase [2,27]. Even in the presence of radon-resistant features, the EPA still recommends that homes should be tested after they have been occupied [2].

Utah's geological landscape renders the whole state vulnerable to the health hazards of indoor radon. However, the culture to test homes for radon is not well established despite the elevated radon exposure presented by Utah's geological potential. Only 20% of surveyed Utahns admitted to having tested their homes for radon while 80% have not tested their homes at all [28]. Additionally, Utah lacks legislation that mandates statewide home testing, mitigation, and the installation of radon-resistant features in new homes [29]. The objectives of this study were to identify and assess among Utah County residents: (1) their opinions on having local and state policies on radon testing and mitigation in homes, schools, and businesses; (2) their viewpoints on the role of policymakers in increasing radon awareness, testing, and remediation at the local and state levels; and (3) whether demographic characteristics and social cognitive theory constructs were associated with respondents' perspectives on radon policies.

2. Materials and Methods

2.1. Study Sample, Design, and IRB Approval

Participants in this cross-sectional study were recruited by convenience sampling from Utah County residents who visited the Utah County Health Department (UCHD) from May 2014–January 2016 [30]. Participants (N = 307) were recruited from among two different groups: (1) the Environmental Health Group (n = 110) consisted of people who specifically visited the UCHD Division of Environmental Health to purchase a radon test kit, and (2) the Vital Records Group (n = 197), which consisted of people who visited the UCHD Vital Records Office to file or obtain birth/death certificates. Individuals visiting the Vital Records Office were specifically selected to serve as a comparison group with the assumption that this group would be demographically representative of the general population in Utah County.

A paper-and-pencil questionnaire, which took about 10 to 15 min to complete, was administered to participants in both groups. For the Environmental Health Group, participants were recruited by two UCHD Environmental Health Division staff who were trained to administer the survey. From May 2014–February 2015, participants in the Environmental Health Group received 50% off the price of the radon test kit (USD 5) as an incentive to join the study. This incentive was later increased to USD 10 off the price for the remainder of the study (March 2015–January 2016) to increase enrollment size and to compensate participants for a follow-up survey on radon mitigation behavior (data not reported).

For the Vital Records Group, the research team set up a table outside of the Vital Records Office and spent approximately six to eight hours per week recruiting participants. The survey ran from May 2014 to January 2016 for this group and participants received a USD 5 cash incentive for completing the survey. All study participants completed a consent form prior to taking the survey. The Institutional Review Board at Brigham Young University approved this study.

2.2. Survey Instrument

A 52-item paper/pencil survey (Supplemental Materials, Radon Testing Survey, p. 2) was developed to assess knowledge of radon, risk perceptions, social cognitive theory (SCT)-based predictors of radon testing, sources of radon information, previous radon testing, attitudes toward radon testing and mitigation policies in Utah, and demographic and housing characteristics. Participants in both groups received the same survey; however, the Environmental Health Group's survey included one additional question on whether participants knew about the incentive before coming to UCHD to purchase a radon test kit. Seven (6%) participants were aware of the USD 5 or USD 10 incentive before coming to UCHD to purchase a radon test kit (i.e., 103 participants, or 94%, were not aware of the incentive).

2.2.1. Radon Knowledge

Four multiple choice questions were used to measure participants' knowledge of radon. Two of these questions were adapted from previous studies and two were developed a priori. Questions adapted from previous studies included, "What is radon?" and "Which of the following is the major health concern caused by exposure to radon?" [31,32]. The questions developed a priori were "What is the main way that radon enters your body?" and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?"

2.2.2. Demographic and Housing Variables

The following demographic and housing variables were included in the survey: age, gender, race/ethnicity, relationship status, educational attainment, and annual household income. Housing characteristics were measured using five items that included length of time participants lived in their current residence, number of people in the home, number of children in the home, home ownership/renting, and type of home.

2.2.3. Perception of Radon Testing Policies

There were five questions developed by one of the researchers to determine participants' support for various potential policies on radon testing and mitigation that could be implemented in Utah. These questions were intended to assess support for laws requiring the testing and reporting of radon levels in homes, schools, and businesses; installing a radon reduction system at the time of home construction; using radon-resistant materials as part of the State's building code; and identifying who respondents believe should assume the responsibility for reporting radon levels to potential homebuyers (builder, seller, buyer, homeowners' association, or local county health department). The last item was an open-ended question on what respondents believe to be the role of local and state policymakers in increasing radon awareness, testing, and remediation at the state level.

2.3. Data Analyses

All statistical analyses were completed using SAS version 9.4 (SAS Institute, Inc., Cary, NC, USA). However, some data cleaning and variable creation had to be completed prior to the statistical analyses (Supplemental Materials, Additional Information Regarding Data Analyses, p. 10).

Frequencies and percentages were calculated for categorical characteristics of participants and radon policy awareness and opinion variables. Means, standard deviations,

minimums, first quartiles, medians, third quartiles, and maximums were calculated for continuous characteristics of participants and radon policy awareness and opinion variables. The variables "aware of any present policy or legal resolution on radon testing and mitigation in the State of Utah" (i.e., question 44) and "should Utah have laws mandating testing and reporting of radon levels in schools" (i.e., question 46) were included only in descriptive analyses because of few responses for one of the answer options.

Several versions of the participants' characteristics variables were created with different numbers of categories in each of them. Simple (unadjusted) unconditional logistic regression models were used to estimate associations between participants' characteristics and opinions of radon policies. The versions of the participants' characteristics variables that had the lowest values of the Akaike Information Criterion (AIC) were used for analyses [33,34]. AIC values were determined using non-imputed data [35].

Multiple imputation was used to impute all missing data in the variables used for analyses [36,37]. The default settings of PROC MI and seed 897,031 were used to impute 100 datasets. The imputation model included all variables included in analyses (Supplemental Materials, Additional Information Regarding Data Analyses, p. 10). Imputed values that were between categories were recoded to the nearest category [36]. For example, if a variable could have a value of zero (e.g., "No") or one (e.g., "Yes"), but SAS imputed a value between zero and one, then all values less than 0.5 were recoded as zero and all values greater than or equal to 0.5 were recoded as one.

Simple (unadjusted) unconditional logistic regression models and PROC MIANALYZE were used to estimate multiply imputed odds ratios (OR) and 95% confidence intervals (CI) for associations between participants' characteristics and opinions of radon policies. Multivariable (adjusted) unconditional logistic regression models and PROC MIANALYZE were used to estimate multiply imputed ORs and 95% CIs for associations between participants' characteristics and opinions of radon policies adjusted for potential confounders. For each characteristic, a different set of potential confounders was identified and adjusted for (Supplemental Materials, Table S1) [38].

Analyses were conducted to determine whether there was effect measure modification by study group of associations between radon knowledge, behavioral modeling, self-efficacy, or risk perception and opinions of radon policies. Effect measure modification was tested by including main effect and interaction terms for study group and radon knowledge, behavioral modeling, self-efficacy, or risk perception in separate simple (unadjusted) unconditional logistic regression models for the opinions of radon policies variables. PROC MIANALYZE was used to combine the regression slope coefficients (i.e., the natural logarithm of the odds ratios) and their standard errors and calculate multiply imputed Wald χ^2 statistics and p-values. A significance level of $\alpha = 0.1$ was used for the effect measure modification analyses.

For the open-ended question on policy, "What do you think your local and state policymakers should do to increase radon awareness, testing, and remediation throughout the state?", a Braun and Clarke's thematic analysis method [39] was carried out to examine the views, opinions, knowledge, and/or experiences of respondents. Using an inductive approach, the main themes were identified based on participants' responses. This was done by being familiar with the data through reading, highlighting, and taking down notes to identify various codes or recurring topics, ideas, feelings, and patterns of meaning. From the codes, themes were generated and reviewed to ensure accurate representation of the participants' responses. Finally, the main themes were analyzed for their meanings and frequency of occurrence as part of ascertaining the key points from the data.

3. Results

Forty-one percent of participants were ages 45 years and above, 57% were female, and 89% were Caucasian (Table 1). Fifty-five percent of participants had completed a Bachelor's degree or greater (i.e., Master's degree, some graduate, or professional/doctorate), 42% had an annual income of USD 65,000 or greater, and 79% were currently married. The

mean number of people and children who lived in the home was 3.76 and 1.55, respectively. Sixty-six percent of participants owned the home they lived in, 69% lived in single-family homes, and the mean number of years participants had lived in their current residence was 9.35. The mean radon knowledge (i.e., number of questions answered correctly out of four) was 2.94. The means for behavioral modeling, self-efficacy, and risk perception were 2.18, 2.93, and 4.18, respectively (the variables were means of three or four survey questions with possible values that ranged from one to five (Supplemental Materials, Additional Information Regarding Data Analyses, p. 10); higher values indicated higher behavioral modeling, self-efficacy, and/or risk perception). Thirty-six percent of participants were from the Environmental Health Group and 10% had ever tested their current home for radon, of which 38% had tested their current home within the last two years. Sixty-nine percent of participants had heard about radon in the past year from TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or a combination of these answers. Nineteen percent of participants had at least one family member who tested their home for radon, 42% had at least one friend or neighbor who tested their home for radon, and 44% had at least one friend, family member, or neighbor who tested their home and found that radon levels in their home were high.

Table 1. Characteristics of radon testing survey participants, Utah County, Utah, May 2014–January 2016.

Characteristic	*n*	%	Missing, *n*	Mean	SD	Min	Q1	Median	Q3	Max
Total	307	100								
Age, years			3							
18–44	179	59								
45 and above	125	41								
Gender			11							
Male	128	43								
Female	168	57								
Race/ethnic background			4							
Caucasian	269	89								
Asian, Pacific Islander, Black or African American, Hispanic/Latino, Native American, biracial, or other	34	11								
Highest grade or degree completed			4							
Less than high school, some high school, high school or earned GED certificate, or some college	137	45								
Bachelor's degree, Master's degree, some graduate, or professional/doctorate (e.g., MD, JD, PhD, DDS, etc.)	166	55								
Current annual family income			12							
Less than USD 15,000 to USD 64,999	170	58								
USD 65,000 or greater	125	42								
Relationship status			8							
Currently married	237	79								
Not married, living with partner; single, never been married and not living with a partner; separated; divorced; or widowed	62	21								
Number of people who live in home [a,b]			6	3.76	1.72	0.00	2.00	4.00	5.00	10.00
0–4	211	70								
5–10	90	30								

Table 1. *Cont.*

Characteristic	*n*	%	Missing, *n*	Mean	SD	Min	Q1	Median	Q3	Max
Number of children who live in home [a]			6	1.55	1.57	0.00	0.00	1.00	3.00	6.00
0–1	165	55								
2–6	136	45								
Own or rent home			5							
Own	200	66								
Rent or other	102	34								
Type of residence live in			6							
Single-family home	209	69								
Townhome or condominium, mobile home or manufactured home, basement apartment, first floor apartment, or second floor apartment or above	92	31								
How long lived in current residence, years [a]			6	9.35	11.19	0.00	1.33	5.00	12.92	55.00
0–5	151	50								
>5–55	150	50								
Radon knowledge [c,d]			224	2.94	1.14	0.00	2.00	3.00	4.00	4.00
Behavioral modeling [a,e,f]			4	2.18	1.12	1.00	1.00	2.00	3.00	5.00
1–2	183	60								
3–5	120	40								
Self-efficacy [e,g]			3	2.93	1.07	1.00	2.00	3.00	3.75	5.00
Risk perception [a,e,h]			4	4.18	0.65	2.33	3.67	4.33	4.67	5.00
1–4	193	64								
5	110	36								
Study group										
Environmental Health	110	36								
Vital Records	197	64								
Before today, ever tested current home for radon [d]			16							
No	262	90								
Yes	29	10								
If yes, how long ago was the test performed										
Within the last two years	11	38								
More than two years ago	18	62								
In the past year, heard about radon from any of the following			12							
TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or combination	205	69								
None	90	31								
Have at least one family member who tested their home for radon [d]			121							
No	151	81								
Yes	35	19								
Have at least one friend or neighbor who tested their home for radon [d]			165							
No	82	58								
Yes	60	42								

Table 1. *Cont.*

Characteristic	*n*	%	Missing, *n*	Mean	SD	Min	Q1	Median	Q3	Max
Have at least one friend, family member, or neighbor who tested their home for radon and found radon levels in their home were high [d,i]			169							
No	66	56								
Yes	52	44								

Abbreviations: Max, maximum; Min, minimum; Q1, first quartile; Q3, third quartile; SD, standard deviation. [a] Category boundaries set at the median of the distribution of this variable. [b] One participant reported being homeless. [c] Number of questions answered correctly out of four. Derived from questions 1–4 (Supplemental Materials, Radon Testing Survey, p. 2), which were "What is radon?", "Which of the following is the major health concern caused by exposure to radon?", "What is the main way that radon enters your body?", and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?", respectively. Variable based on results from Davis et al. [30]. [d] "I don't know" answers were recoded as missing values. [e] Means with possible values that ranged from one to five. [f] Derived from questions 7–9 (Supplemental Materials, Radon Testing Survey, p. 2), which were "At least one of my family members has encouraged me to test my home for radon", "At least one of my friends has encouraged me to test my home for radon", and "At least one of my neighbors has encouraged me to test my home for radon", respectively. Variable based on results from Davis et al. [30]. [g] Derived from questions 20–22 and 24 (Supplemental Materials, Radon Testing Survey, p. 2), which were "I do not know where to buy a radon testing kit", "I know who to contact to learn more about radon testing", "I know how to test my home for radon", and "I can find help to test my home for radon", respectively. Responses to question 20 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [h] Derived from questions 15, 16, and 19 (Supplemental Materials, Radon Testing Survey, p. 2), which were "It is important to me that I know if there are unseen health risks in my home", "It is important to me that I know the radon levels in my home", and "I am not worried about radon making me sick", respectively. Responses to question 19 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [i] Twenty participants were excluded from analyses of this variable because they answered "Not applicable".

Ninety-nine percent of respondents were not aware of any present policy or legal resolution on radon testing and mitigation in the State of Utah, 81% responded Utah should have laws mandating detection and reporting of radon levels in homes, and 98% responded Utah should have laws mandating testing and reporting of radon levels in schools (Table 2). Eighty-five percent of participants responded Utah should have laws mandating detection and reporting of radon levels in businesses, 89% responded radon testing and mitigation should be included in building codes in Utah, and 92% responded use of radon-resistant materials should be required in building codes in Utah. The mean number of radon policy opinion questions (out of five) for which participants answered "Yes" was 4.51. Regarding the responsibility to disclose radon levels to potential homebuyers in the State of Utah, 34% believed that it was the home seller's responsibility; 21% considered it be the home association's responsibility or a combination of the answers; 17% placed the responsibility on the local county health department; 16% considered it to be the homebuilder's responsibility, and 12% believed it to be the home buyer's responsibility.

In unadjusted, multiply imputed analyses, responding that Utah should have laws mandating the detection and reporting of radon levels in homes was significantly inversely associated with being ages 45 years and above compared to ages 18–44 and having ever tested their current home for radon compared to having not ever tested their current home for radon, but significantly positively associated with being female compared to male, having a current annual family income less than USD 15,000 to USD 64,999 compared to USD 65,000 or greater, and having a risk perception of five compared to 1–4 (Table 3). In adjusted, multiply imputed analyses, the same opinion was significantly positively associated with having a behavioral modeling of 3–5 compared to 1–2 and having a risk perception of five compared to 1–4.

In unadjusted, multiply imputed analyses, responding that Utah should have laws mandating detection and reporting of radon levels in businesses was significantly positively associated with being female compared to male, having a current annual family income less than USD 15,000 to USD 64,999 compared to USD 65,000 or greater, and having a risk perception of five compared to 1–4 (Table 4). In adjusted, multiply imputed analyses, the same opinion was significantly positively associated with having a current annual family income less than USD 15,000 to USD 64,999 compared to USD 65,000 or greater, having a

behavioral modeling of 3–5 compared to 1–2, and having a risk perception of five compared to 1–4.

In unadjusted, multiply imputed analyses, responding that radon testing and mitigation should be included in building codes in Utah was significantly inversely associated with being ages 45 years and above compared to ages 18–44, a one unit increase in self-efficacy, and being in the Environmental Health Group compared to the Vital Records Group, but significantly positively associated with being female compared to male and having a current annual family income less than USD 15,000 to USD 64,999 compared to USD 65,000 or greater (Table 5). In adjusted, multiply imputed analyses, the same opinion was not significantly associated with any participant characteristic.

In unadjusted, multiply imputed analyses, responding that use of radon-resistant materials should be required in building codes in Utah was significantly inversely associated with a one unit increase in self-efficacy, but significantly positively associated with being female compared to male (Table 6). In adjusted, multiply imputed analyses, the same opinion was significantly positively associated with having a risk perception of five compared to 1–4.

In unadjusted, multiply imputed analyses, answering "Yes" for five compared to 0–4 radon policy opinion questions was significantly inversely associated with being ages 45 years and above compared to ages 18–44 and having ever tested their current home for radon compared to having not ever tested their current home for radon, but significantly positively associated with being female compared to male, having a current annual family income less than USD 15,000 to USD 64,999 compared to USD 65,000 or greater, having a behavioral modeling of 3–5 compared to 1–2, and having a risk perception of five compared to 1–4 (Table 7). In adjusted, multiply imputed analyses, the same answer was significantly positively associated with having a behavioral modeling of 3–5 compared to 1–2 and having a risk perception of five compared to 1–4.

Table 2. Awareness and opinions of radon policies among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

Variable	*n*	%	Missing, *n*	Mean	SD	Min	Q1	Median	Q3	Max
Total	307	100								
Aware of any present policy or legal resolution on radon testing and mitigation in the State of Utah			5							
No	299	99								
Yes	3	1								
Should Utah have laws mandating detection and reporting of radon levels in homes [a]			157							
No	28	19								
Yes	122	81								
Should Utah have laws mandating testing and reporting of radon levels in schools [a]			73							
No	5	2								
Yes	229	98								
Should Utah have laws mandating detection and reporting of radon levels in businesses [a]			116							
No	29	15								
Yes	162	85								

Table 2. *Cont.*

Variable	*n*	%	Missing, *n*	Mean	SD	Min	Q1	Median	Q3	Max
Should radon testing and mitigation be included in building codes in Utah [a]			120							
No	20	11								
Yes	167	89								
Should use of radon-resistant materials be required in building codes in Utah [a]			116							
No	15	8								
Yes	176	92								
Number of radon policy opinion questions (out of five) for which participants answered "Yes" [a]			204	4.51	1.20	0.00	5.00	5.00	5.00	5.00
0–4	18	17								
5	85	83								
Who should be responsible for disclosing radon levels to potential homebuyers in the State of Utah			6							
It is the homebuilder's responsibility	48	16								
It is the home seller's responsibility	101	34								
It is the homebuyer's responsibility	36	12								
It is the local county health department's responsibility	52	17								
It is the home association's responsibility or combination	64	21								

Abbreviations: Max, maximum; Min, minimum; Q1, first quartile; Q3, third quartile; SD, standard deviation. [a] "I don't know" and "I am not interested in this issue" answers were recoded as missing values.

Table 3. Unadjusted and adjusted, multiply imputed associations between characteristics and opinions regarding whether Utah should have laws mandating detection and reporting of radon levels in homes among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Homes (Yes vs. No)								
	Yes		**No**		**Missing**	**Unadjusted [a], MI [b]**		**Adjusted [c], MI [b]**	
Characteristic	***n***	**%**	**No**	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Age, years									
18–44	71	59	7	25	101	1.00	Reference	NA	NA
45 and above	49	41	21	75	55	0.37	0.18, 0.77	NA	NA
Missing	2		0		1				
Gender									
Male	44	38	22	79	62	1.00	Reference	NA	NA
Female	71	62	6	21	91	3.57	1.65, 7.70	NA	NA
Missing	7		0		4				
Race/ethnic background									
Caucasian	97	81	26	93	146	1.00	Reference	NA	NA
Asian, Pacific Islander, Black or African American, Hispanic/Latino, Native American, biracial, or other	23	19	2	7	9	2.03	0.56, 7.27	NA	NA
Missing	2		0		2				
Highest grade or degree completed									
Less than high school, some high school, high school or earned GED certificate, or some college	54	44	7	25	76	1.00	Reference	1.00	Reference
Bachelor's degree, Master's degree, some graduate, or professional/doctorate (e.g., MD, JD, PhD, DDS, etc.)	68	56	21	75	77	0.75	0.37, 1.54	0.97 [d]	0.44, 2.11 [d]
Missing	0		0		4				
Current annual family income									
Less than USD 15,000 to USD 64,999	70	58	8	31	92	2.14	1.04, 4.41	1.85 [e]	0.87, 3.96 [e]
USD 65,000 or greater	51	42	18	69	56	1.00	Reference	1.00	Reference
Missing	1		2		9				
Relationship status									
Currently married	93	77	24	86	120	1.00	Reference	1.00	Reference
Not married, living with partner; single, never been married and not living with a partner; separated; divorced; or widowed	28	23	4	14	30	1.37	0.53, 3.53	1.41 [f]	0.53, 3.73 [f]
Missing	1		0		7				

Table 3. *Cont.*

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Homes (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	**No**	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Number of people who live in home [g,h]									
0–4	85	70	19	68	107	1.00	Reference	1.00	Reference
5–10	37	30	9	32	44	0.98	0.48, 2.03	0.84 [i]	0.37, 1.88 [i]
Missing	0		0		6				
Number of children who live in home [g]									
0–1	71	58	17	61	77	1.00	Reference	1.00	Reference
2–6	51	42	11	39	74	0.90	0.46, 1.76	0.71 [i]	0.32, 1.60 [i]
Missing	0		0		6				
Own or rent home									
Own	85	70	24	86	91	1.00	Reference	1.00	Reference
Rent or other	37	30	4	14	61	1.59	0.70, 3.63	0.53 [i]	0.17, 1.60 [i]
Missing	0		0		5				
Type of residence live in									
Single-family home	87	71	25	89	97	1.00	Reference	1.00	Reference
Townhome or condominium, mobile home or manufactured home, basement apartment, first floor apartment, or second floor apartment or above	35	29	3	11	54	1.85	0.76, 4.51	1.17 [i]	0.43, 3.15 [i]
Missing	0		0		6				
How long lived in current residence, years [g]									
0–5	67	55	7	25	77	1.00	Reference	1.00	Reference
>5–55	55	45	21	75	74	0.57	0.29, 1.13	1.01 [j]	0.41, 2.53 [j]
Missing	0		0		6				
Radon knowledge, one question change [k]						0.70	0.46, 1.06	0.78 [l]	0.49, 1.25 [l]
Missing	78		19		127				
Behavioral modeling [g,m,n]									
1–2	61	50	19	68	103	1.00	Reference	1.00	Reference
3–5	60	50	9	32	51	1.94	0.92, 4.06	2.33 [l]	1.07, 5.05 [l]
Missing	1		0		3				

Table 3. *Cont.*

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Homes (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	**No**	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Self-efficacy, one unit change [m,o]						0.78	0.57, 1.08	0.96 [p]	0.66, 1.41 [p]
Missing	0		0		3				
Risk perception [g,m,q]									
1–4	53	44	21	75	119	1.00	Reference	1.00	Reference
5	68	56	7	25	35	2.21	1.03, 4.75	2.97 [r]	1.27, 6.93 [r]
Missing	1		0		3				
Study group									
Environmental Health	55	45	15	54	40	0.81	0.41, 1.60	4.00 [s]	0.92, 17.49 [s]
Vital Records	67	55	13	46	117	1.00	Reference	1.00	Reference
Before today, ever tested current home for radon									
No	112	93	22	79	128	1.00	Reference	1.00	Reference
Yes	8	7	6	21	15	0.30	0.12, 0.76	0.49 [t]	0.15, 1.59 [t]
Missing	2		0		14				
In the past year, heard about radon from any of the following									
TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or combination	89	74	25	89	91	0.87	0.39, 1.97	NA	NA
None	31	26	3	11	56	1.00	Reference	NA	NA
Missing	2		0		10				
Have at least one family member who tested their home for radon									
No	73	81	18	78	60	1.00	Reference	1.00	Reference
Yes	17	19	5	22	13	0.68	0.29, 1.56	0.68 [l]	0.28, 1.65 [l]
Missing	32		5		84				
Have at least one friend or neighbor who tested their home for radon									
No	42	60	12	71	28	1.00	Reference	1.00	Reference
Yes	28	40	5	29	27	1.44	0.64, 3.28	1.58 [l]	0.66, 3.77 [l]
Missing	52		11		102				

Table 3. *Cont.*

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Homes (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	**No**	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Have at least one friend, family member, or neighbor who tested their home for radon and found radon levels in their home were high [u]									
No	33	57	12	75	21	1.00	Reference	1.00	Reference
Yes	25	43	4	25	23	1.12	0.49, 2.56	1.16 [l]	0.48, 2.78 [l]
Missing	57		12		100				

Abbreviations: CI, confidence interval; MI, multiply imputed; NA, not applicable; OR, odds ratio. [a] Estimated via simple (unadjusted) unconditional logistic regression models. [b] The imputation model we used for multiple imputation included the 21 characteristics shown in this table and the five radon policy opinion questions shown in Table 2. We imputed 100 datasets. [c] Estimated via multivariable (adjusted) unconditional logistic regression models. [d] Adjusted for age, gender, and race/ethnic background using the versions of these variables shown in this table. [e] Adjusted for age and relationship status using the versions of these variables shown in this table. [f] Adjusted for age and race/ethnic background using the versions of these variables shown in this table. [g] Category boundaries set at the median of the distribution of this variable. [h] One participant reported being homeless. [i] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, and relationship status using the versions of these variables shown in this table. [j] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, and own or rent home using the versions of these variables shown in this table. [k] Number of questions answered correctly out of four. Derived from questions 1–4 (Supplemental Materials, Radon Testing Survey, p. 2), which were "What is radon?", "Which of the following is the major health concern caused by exposure to radon?", "What is the main way that radon enters your body?", and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?", respectively. Variable based on results from Davis et al. [30]. [l] Adjusted for age, highest grade or degree completed, and own or rent home using the versions of these variables shown in this table. [m] Means with possible values that ranged from one to five. [n] Derived from questions 7–9 (Supplemental Materials, Radon Testing Survey, p. 2), which were "At least one of my family members has encouraged me to test my home for radon", "At least one of my friends has encouraged me to test my home for radon", and "At least one of my neighbors has encouraged me to test my home for radon", respectively. Variable based on results from Davis et al. [30]. [o] Derived from questions 20–22 and 24 (Supplemental Materials, Radon Testing Survey, p. 2), which were "I do not know where to buy a radon testing kit", "I know who to contact to learn more about radon testing", "I know how to test my home for radon", and "I can find help to test my home for radon", respectively. Responses to question 20 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [p] Adjusted for age and highest grade or degree completed using the versions of these variables shown in this table. [q] Derived from questions 15, 16, and 19 (Supplemental Materials, Radon Testing Survey, p. 2), which were "It is important to me that I know if there are unseen health risks in my home", "It is important to me that I know the radon levels in my home", and "I am not worried about radon making me sick", respectively. Responses to question 19 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [r] Adjusted for highest grade or degree completed, relationship status, and radon knowledge using the versions of these variables shown in this table. [s] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, risk perception, and before today, ever tested current home for radon using the versions of these variables shown in this table. [t] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, and risk perception using the versions of these variables shown in this table. [u] Twenty participants were excluded from analyses of this variable because they answered "Not applicable".

Table 4. Unadjusted and adjusted, multiply imputed associations between characteristics and opinions regarding whether Utah should have laws mandating detection and reporting of radon levels in businesses among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Businesses (Yes vs. No)								
	Yes		**No**		**Missing**	**Unadjusted [a], MI [b]**		**Adjusted [c], MI [b]**	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Age, years									
18–44	97	61	13	45	69	1.00	Reference	NA	NA
45 and above	63	39	16	55	46	0.74	0.35, 1.57	NA	NA
Missing	2		0		1				
Gender									
Male	63	41	21	72	44	1.00	Reference	NA	NA
Female	91	59	8	28	69	2.60	1.20, 5.64	NA	NA
Missing	8		0		3				
Race/ethnic background									
Caucasian	135	84	28	97	106	1.00	Reference	NA	NA
Asian, Pacific Islander, Black or African American, Hispanic/Latino, Native American, biracial, or other	25	16	1	3	8	2.42	0.51, 11.43	NA	NA
Missing	2		0		2				
Highest grade or degree completed									
Less than high school, some high school, high school or earned GED certificate, or some college	72	44	8	28	57	1.00	Reference	1.00	Reference
Bachelor's degree, Master's degree, some graduate, or professional/doctorate (e.g., MD, JD, PhD, DDS, etc.)	90	56	21	72	55	0.71	0.33, 1.53	0.84 [d]	0.38, 1.87 [d]
Missing	0		0		4				
Current annual family income									
Less than USD 15,000 to USD 64,999	96	60	7	25	67	2.43	1.17, 5.05	2.27 [e]	1.07, 4.81 [e]
USD 65,000 or greater	64	40	21	75	40	1.00	Reference	1.00	Reference
Missing	2		1		9				
Relationship status									
Currently married	123	77	26	90	88	1.00	Reference	1.00	Reference
Not married, living with partner; single, never been married and not living with a partner; separated; divorced; or widowed	37	23	3	10	22	1.64	0.57, 4.65	1.62 [f]	0.56, 4.65 [f]
Missing	2		0		6				

Table 4. *Cont.*

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Businesses (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Number of people who live in home [g,h]									
0–4	111	69	19	66	81	1.00	Reference	1.00	Reference
5–10	50	31	10	34	30	0.94	0.44, 2.00	1.08 [i]	0.46, 2.53 [i]
Missing	1		0		5				
Number of children who live in home [g]									
0–1	91	57	12	41	62	1.00	Reference	1.00	Reference
2–6	70	43	17	59	49	0.65	0.32, 1.31	0.70 [i]	0.30, 1.63 [i]
Missing	1		0		5				
Own or rent home									
Own	111	69	23	79	66	1.00	Reference	1.00	Reference
Rent or other	51	31	6	21	45	1.17	0.52, 2.64	0.46 [i]	0.15, 1.40 [i]
Missing	0		0		5				
Type of residence live in									
Single-family home	120	74	24	83	65	1.00	Reference	1.00	Reference
Townhome or condominium, mobile home or manufactured home, basement apartment, first floor apartment, or second floor apartment or above	42	26	5	17	45	1.04	0.46, 2.37	0.62 [i]	0.24, 1.63 [i]
Missing	0		0		6				
How long lived in current residence, years [g]									
0–5	81	50	10	34	60	1.00	Reference	1.00	Reference
>5–55	81	50	19	66	50	0.80	0.37, 1.70	1.02 [j]	0.38, 2.74 [j]
Missing	0		0		6				
Radon knowledge, one question change [k]						0.78	0.51, 1.21	0.80 [l]	0.49, 1.29 [l]
Missing	101		22		101				
Behavioral modeling [g,m,n]									
1–2	87	54	23	79	73	1.00	Reference	1.00	Reference
3–5	73	46	6	21	41	2.37	0.97, 5.80	2.55 [l]	1.02, 6.35 [l]
Missing	2		0		2				

Table 4. *Cont.*

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Businesses (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Self-efficacy, one unit change [m,o]						0.84	0.60, 1.16	0.89 [p]	0.62, 1.30 [p]
Missing	1		0		2				
Risk perception [g,m,q]									
1–4	87	54	24	83	82	1.00	Reference	1.00	Reference
5	73	46	5	17	32	2.88	1.16, 7.14	3.71 [r]	1.43, 9.62 [r]
Missing	2		0		2				
Study group									
Environmental Health	62	38	12	41	36	1.10	0.52, 2.33	3.90 [s]	0.86, 17.75 [s]
Vital Records	100	62	17	59	80	1.00	Reference	1.00	Reference
Before today, ever tested current home for radon									
No	145	92	24	83	93	1.00	Reference	1.00	Reference
Yes	13	8	5	17	11	0.56	0.20, 1.59	1.07 [t]	0.29, 4.01 [t]
Missing	4		0		12				
In the past year, heard about radon from any of the following									
TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or combination	118	74	24	83	63	1.04	0.44, 2.43	NA	NA
None	41	26	5	17	44	1.00	Reference	NA	NA
Missing	3		0		9				
Have at least one family member who tested their home for radon									
No	94	82	16	73	41	1.00	Reference	1.00	Reference
Yes	21	18	6	27	8	0.61	0.26, 1.41	0.62 [l]	0.26, 1.48 [l]
Missing	47		7		67				
Have at least one friend or neighbor who tested their home for radon									
No	49	57	10	77	23	1.00	Reference	1.00	Reference
Yes	37	43	3	23	20	1.28	0.52, 3.17	1.33 [l]	0.52, 3.41 [l]
Missing	76		16		73				

Table 4. *Cont.*

	Should Utah Have Laws Mandating Detection and Reporting of Radon Levels in Businesses (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Have at least one friend, family member, or neighbor who tested their home for radon and found radon levels in their home were high [u]									
No	39	56	8	73	19	1.00	Reference	1.00	Reference
Yes	31	44	3	27	18	0.86	0.32, 2.27	0.87 [l]	0.32, 2.35 [l]
Missing	84		16		69				

Abbreviations: CI, confidence interval; MI, multiply imputed; NA, not applicable; OR, odds ratio. [a] Estimated via simple (unadjusted) unconditional logistic regression models. [b] The imputation model we used for multiple imputation included the 21 characteristics shown in this table and the five radon policy opinion questions shown in Table 2. We imputed 100 datasets. [c] Estimated via multivariable (adjusted) unconditional logistic regression models. [d] Adjusted for age, gender, and race/ethnic background using the versions of these variables shown in this table. [e] Adjusted for age and relationship status using the versions of these variables shown in this table. [f] Adjusted for age and race/ethnic background using the versions of these variables shown in this table. [g] Category boundaries set at the median of the distribution of this variable. [h] One participant reported being homeless. [i] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, and relationship status using the versions of these variables shown in this table. [j] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, and own or rent home using the versions of these variables shown in this table. [k] Number of questions answered correctly out of four. Derived from questions 1–4 (Supplemental Materials, Radon Testing Survey, p. 2), which were "What is radon?", "Which of the following is the major health concern caused by exposure to radon?", "What is the main way that radon enters your body?", and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?", respectively. Variable based on results from Davis et al. [30]. [l] Adjusted for age, highest grade or degree completed, and own or rent home using the versions of these variables shown in this table. [m] Means with possible values that ranged from one to five. [n] Derived from questions 7–9 (Supplemental Materials, Radon Testing Survey, p. 2), which were "At least one of my family members has encouraged me to test my home for radon", "At least one of my friends has encouraged me to test my home for radon", and "At least one of my neighbors has encouraged me to test my home for radon", respectively. Variable based on results from Davis et al. [30]. [o] Derived from questions 20–22 and 24 (Supplemental Materials, Radon Testing Survey, p. 2), which were "I do not know where to buy a radon testing kit", "I know who to contact to learn more about radon testing", "I know how to test my home for radon", and "I can find help to test my home for radon", respectively. Responses to question 20 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [p] Adjusted for age and highest grade or degree completed using the versions of these variables shown in this table. [q] Derived from questions 15, 16, and 19 (Supplemental Materials, Radon Testing Survey, p. 2), which were "It is important to me that I know if there are unseen health risks in my home", "It is important to me that I know the radon levels in my home", and "I am not worried about radon making me sick", respectively. Responses to question 19 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [r] Adjusted for highest grade or degree completed, relationship status, and radon knowledge using the versions of these variables shown in this table. [s] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, risk perception, and before today, ever tested current home for radon using the versions of these variables shown in this table. [t] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, and risk perception using the versions of these variables shown in this table. [u] Twenty participants were excluded from analyses of this variable because they answered "Not applicable".

Table 5. Unadjusted and adjusted, multiply imputed associations between characteristics and opinions regarding whether radon testing and mitigation should be included in building codes in Utah among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

	Should Radon Testing and Mitigation Be Included in Building Codes in Utah (Yes vs. No)								
	Yes		**No**		**Missing**	**Unadjusted [a], MI [b]**		**Adjusted [c], MI [b]**	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Age, years									
18–44	101	61	6	30	72	1.00	Reference	NA	NA
45 and above	65	39	14	70	46	0.39	0.17, 0.88	NA	NA
Missing	1		0		2				
Gender									
Male	62	39	17	85	49	1.00	Reference	NA	NA
Female	98	61	3	15	67	5.77	2.12, 15.73	NA	NA
Missing	7		0		4				
Race/ethnic background									
Caucasian	140	85	18	90	111	1.00	Reference	NA	NA
Asian, Pacific Islander, Black or African American, Hispanic/Latino, Native American, biracial, or other	25	15	2	10	7	2.17	0.48, 9.69	NA	NA
Missing	2		0		2				
Highest grade or degree completed									
Less than high school, some high school, high school or earned GED certificate, or some college	75	45	3	15	59	1.00	Reference	1.00	Reference
Bachelor's degree, Master's degree, some graduate, or professional/doctorate (e.g., MD, JD, PhD, DDS, etc.)	91	55	17	85	58	0.50	0.20, 1.26	0.67 [d]	0.25, 1.76 [d]
Missing	1		0		3				
Current annual family income									
Less than USD 15,000 to USD 64,999	94	58	4	20	72	2.33	1.00, 5.38	1.81 [e]	0.76, 4.31 [e]
USD 65,000 or greater	69	42	16	80	40	1.00	Reference	1.00	Reference
Missing	4		0		8				
Relationship status									
Currently married	125	77	18	95	94	1.00	Reference	1.00	Reference
Not married, living with partner; single, never been married and not living with a partner; separated; divorced; or widowed	38	23	1	5	23	2.66	0.69, 10.28	2.76 [f]	0.70, 10.81 [f]
Missing	4		1		3				

Table 5. *Cont.*

	Should Radon Testing and Mitigation Be Included in Building Codes in Utah (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Number of people who live in home [g,h]									
0–4	112	68	12	60	87	1.00	Reference	1.00	Reference
5–10	52	32	8	40	30	0.96	0.42, 2.20	0.87 [i]	0.34, 2.18 [i]
Missing	3		0		3				
Number of children who live in home [g]									
0–1	89	54	10	50	66	1.00	Reference	1.00	Reference
2–6	75	46	10	50	51	0.98	0.45, 2.16	0.90 [i]	0.36, 2.27 [i]
Missing	3		0		3				
Own or rent home									
Own	114	69	18	90	68	1.00	Reference	1.00	Reference
Rent or other	52	31	2	10	48	1.77	0.67, 4.69	0.49 [i]	0.14, 1.78 [i]
Missing	1		0		4				
Type of residence live in									
Single-family home	123	74	17	89	69	1.00	Reference	1.00	Reference
Townhome or condominium, mobile home or manufactured home, basement apartment, first floor apartment, or second floor apartment or above	43	26	2	11	47	1.40	0.55, 3.58	0.74 [i]	0.24, 2.23 [i]
Missing	1		1		4				
How long lived in current residence, years [g]									
0–5	81	49	6	30	64	1.00	Reference	1.00	Reference
>5–55	84	51	14	70	52	0.68	0.31, 1.52	1.38 [j]	0.47, 4.04 [j]
Missing	2		0		4				
Radon knowledge, one question change [k]						0.60	0.34, 1.05	0.67 [l]	0.38, 1.18 [l]
Missing	113		11		100				
Behavioral modeling [g,m,n]									
1–2	87	53	14	70	82	1.00	Reference	1.00	Reference
3–5	78	47	6	30	36	2.02	0.85, 4.83	2.41 [l]	0.98, 5.94 [l]
Missing	2		0		2				

Table 5. *Cont.*

	Should Radon Testing and Mitigation Be Included in Building Codes in Utah (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Self-efficacy, one unit change [m,o]						0.58	0.39, 0.87	0.68 [p]	0.44, 1.05 [p]
Missing	1		0		2				
Risk perception [g,m,q]									
1–4	90	54	14	70	89	1.00	Reference	1.00	Reference
5	76	46	6	30	28	1.56	0.67, 3.62	2.28 [r]	0.93, 5.62 [r]
Missing	1		0		3				
Study group									
Environmental Health	66	40	14	70	30	0.41	0.18, 0.94	1.27 [s]	0.27, 6.07 [s]
Vital Records	101	60	6	30	90	1.00	Reference	1.00	Reference
Before today, ever tested current home for radon									
No	145	90	15	75	102	1.00	Reference	1.00	Reference
Yes	16	10	5	25	8	0.38	0.13, 1.08	0.83 [t]	0.24, 2.91 [t]
Missing	6		0		10				
In the past year, heard about radon from any of the following									
TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or combination	126	77	18	90	61	0.78	0.30, 2.02	NA	NA
None	38	23	2	10	50	1.00	Reference	NA	NA
Missing	3		0		9				
Have at least one family member who tested their home for radon									
No	87	81	11	65	53	1.00	Reference	1.00	Reference
Yes	20	19	6	35	9	0.67	0.27, 1.68	0.72 [l]	0.28, 1.86 [l]
Missing	60		3		58				
Have at least one friend or neighbor who tested their home for radon									
No	43	52	7	58	32	1.00	Reference	1.00	Reference
Yes	39	48	5	42	16	1.15	0.47, 2.86	1.27 [l]	0.49, 3.33 [l]
Missing	85		8		72				

Table 5. *Cont.*

	Should Radon Testing and Mitigation Be Included in Building Codes in Utah (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Have at least one friend, family member, or neighbor who tested their home for radon and found radon levels in their home were high [u]									
No	36	53	5	45	25	1.00	Reference	1.00	Reference
Yes	32	47	6	55	14	1.05	0.38, 2.89	1.11 [l]	0.38, 3.24 [l]
Missing	93		8		68				

Abbreviations: CI, confidence interval; MI, multiply imputed; NA, not applicable; OR, odds ratio. [a] Estimated via simple (unadjusted) unconditional logistic regression models. [b] The imputation model we used for multiple imputation included the 21 characteristics shown in this table and the five radon policy opinion questions shown in Table 2. We imputed 100 datasets. [c] Estimated via multivariable (adjusted) unconditional logistic regression models. [d] Adjusted for age, gender, and race/ethnic background using the versions of these variables shown in this table. [e] Adjusted for age and relationship status using the versions of these variables shown in this table. [f] Adjusted for age and race/ethnic background using the versions of these variables shown in this table. [g] Category boundaries set at the median of the distribution of this variable. [h] One participant reported being homeless. [i] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, and relationship status using the versions of these variables shown in this table. [j] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, and own or rent home using the versions of these variables shown in this table. [k] Number of questions answered correctly out of four. Derived from questions 1–4 (Supplemental Materials, Radon Testing Survey, p. 2), which were "What is radon?", "Which of the following is the major health concern caused by exposure to radon?", "What is the main way that radon enters your body?", and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?", respectively. Variable based on results from Davis et al. [30]. [l] Adjusted for age, highest grade or degree completed, and own or rent home using the versions of these variables shown in this table. [m] Means with possible values that ranged from one to five. [n] Derived from questions 7–9 (Supplemental Materials, Radon Testing Survey, p. 2), which were "At least one of my family members has encouraged me to test my home for radon", "At least one of my friends has encouraged me to test my home for radon", and "At least one of my neighbors has encouraged me to test my home for radon", respectively. Variable based on results from Davis et al. [30]. [o] Derived from questions 20–22 and 24 (Supplemental Materials, Radon Testing Survey, p. 2), which were "I do not know where to buy a radon testing kit", "I know who to contact to learn more about radon testing", "I know how to test my home for radon", and "I can find help to test my home for radon", respectively. Responses to question 20 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [p] Adjusted for age and highest grade or degree completed using the versions of these variables shown in this table. [q] Derived from questions 15, 16, and 19 (Supplemental Materials, Radon Testing Survey, p. 2), which were "It is important to me that I know if there are unseen health risks in my home", "It is important to me that I know the radon levels in my home", and "I am not worried about radon making me sick", respectively. Responses to question 19 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [r] Adjusted for highest grade or degree completed, relationship status, and radon knowledge using the versions of these variables shown in this table. [s] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, risk perception, and before today, ever tested current home for radon using the versions of these variables shown in this table. [t] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, and risk perception using the versions of these variables shown in this table. [u] Twenty participants were excluded from analyses of this variable because they answered "Not applicable".

Table 6. Unadjusted and adjusted, multiply imputed associations between characteristics and opinions regarding whether use of radon-resistant materials should be required in building codes in Utah among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

	Should Use of Radon-Resistant Materials Be Required in Building Codes in Utah (Yes vs. No)								
	Yes		**No**		**Missing**	**Unadjusted [a], MI [b]**		**Adjusted [c], MI [b]**	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Age, years									
18–44	104	59	7	47	68	1.00	Reference	NA	NA
45 and above	71	41	8	53	46	0.66	0.27, 1.64	NA	NA
Missing	1		0		2				
Gender									
Male	66	39	14	93	48	1.00	Reference	NA	NA
Female	105	61	1	7	62	7.79	2.10, 28.96	NA	NA
Missing	5		0		6				
Race/ethnic background									
Caucasian	149	86	14	93	106	1.00	Reference	NA	NA
Asian, Pacific Islander, Black or African American, Hispanic/Latino, Native American, biracial, or other	25	14	1	7	8	2.87	0.37, 22.05	NA	NA
Missing	2		0		2				
Highest grade or degree completed									
Less than high school, some high school, high school or earned GED certificate, or some college	73	42	3	20	61	1.00	Reference	1.00	Reference
Bachelor's degree, Master's degree, some graduate, or professional/doctorate (e.g., MD, JD, PhD, DDS, etc.)	102	58	12	80	52	0.50	0.18, 1.39	0.64 [d]	0.22, 1.89 [d]
Missing	1		0		3				
Current annual family income									
Less than USD 15,000 to USD 64,999	98	57	4	27	68	2.38	0.89, 6.35	1.96 [e]	0.72, 5.35 [e]
USD 65,000 or greater	74	43	11	73	40	1.00	Reference	1.00	Reference
Missing	4		0		8				
Relationship status									
Currently married	131	76	13	93	93	1.00	Reference	1.00	Reference
Not married, living with partner; single, never been married and not living with a partner; separated; divorced; or widowed	41	24	1	7	20	3.84	0.57, 25.69	3.83 [f]	0.57, 25.89 [f]

Table 6. *Cont.*

	Should Use of Radon-Resistant Materials Be Required in Building Codes in Utah (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Missing	4		1		3				
Number of people who live in home [g,h]									
0–4	120	69	9	60	82	1.00	Reference	1.00	Reference
5–10	53	31	6	40	31	0.73	0.28, 1.86	0.78 [i]	0.28, 2.21 [i]
Missing	3		0		3				
Number of children who live in home [g]									
0–1	94	54	7	47	64	1.00	Reference	1.00	Reference
2–6	79	46	8	53	49	0.84	0.34, 2.12	1.02 [i]	0.35, 2.99 [i]
Missing	3		0		3				
Own or rent home									
Own	121	69	11	73	68	1.00	Reference	1.00	Reference
Rent or other	54	31	4	27	44	1.25	0.44, 3.58	0.38 [i]	0.09, 1.57 [i]
Missing	1		0		4				
Type of residence live in									
Single-family home	125	71	10	71	74	1.00	Reference	1.00	Reference
Townhome or condominium, mobile home or manufactured home, basement apartment, first floor apartment, or second floor apartment or above	50	29	4	29	39	1.19	0.42, 3.33	0.68 [i]	0.20, 2.27 [i]
Missing	1		1		4				
How long lived in current residence, years [g]									
0–5	87	50	5	33	59	1.00	Reference	1.00	Reference
>5–55	87	50	10	67	53	0.70	0.27, 1.81	0.87 [j]	0.26, 2.95 [j]
Missing	2		0		4				
Radon knowledge, one question change [k]						0.69	0.39, 1.22	0.71 [l]	0.39, 1.31 [l]
Missing	119		9		96				
Behavioral modeling [g,m,n]									
1–2	93	53	10	67	80	1.00	Reference	1.00	Reference
3–5	81	47	5	33	34	1.53	0.59, 3.97	1.64 [l]	0.62, 4.35 [l]
Missing	2		0		2				

Table 6. *Cont.*

	Should Use of Radon-Resistant Materials Be Required in Building Codes in Utah (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Self-efficacy, one unit change [m,o]						0.61	0.39, 0.96	0.64 [p]	0.40, 1.05 [p]
Missing	1		0		2				
Risk perception [g,m,q]									
1–4	93	53	13	87	87	1.00	Reference	1.00	Reference
5	81	47	2	13	27	2.28	0.76, 6.83	3.18 [r]	1.01, 10.06 [r]
Missing	2		0		2				
Study group									
Environmental Health	67	38	7	47	36	0.57	0.23, 1.40	1.25 [s]	0.21, 7.53 [s]
Vital Records	109	62	8	53	80	1.00	Reference	1.00	Reference
Before today, ever tested current home for radon									
No	155	91	11	73	96	1.00	Reference	1.00	Reference
Yes	16	9	4	27	9	0.41	0.12, 1.34	0.81 [t]	0.19, 3.52 [t]
Missing	5		0		11				
In the past year, heard about radon from any of the following									
TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or combination	129	75	10	67	66	1.09	0.40, 2.95	NA	NA
None	44	25	5	33	41	1.00	Reference	NA	NA
Missing	3		0		9				
Have at least one family member who tested their home for radon									
No	100	83	7	64	44	1.00	Reference	1.00	Reference
Yes	21	17	4	36	10	0.74	0.25, 2.26	0.80 [l]	0.26, 2.50 [l]
Missing	55		4		62				
Have at least one friend or neighbor who tested their home for radon									
No	51	54	5	63	26	1.00	Reference	1.00	Reference
Yes	43	46	3	38	14	1.52	0.53, 4.39	1.62 [l]	0.55, 4.77 [l]
Missing	82		7		76				

Table 6. *Cont.*

	Should Use of Radon-Resistant Materials Be Required in Building Codes in Utah (Yes vs. No)								
	Yes		No		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Have at least one friend, family member, or neighbor who tested their home for radon and found radon levels in their home were high [u]									
No	39	53	4	50	23	1.00	Reference	1.00	Reference
Yes	34	47	4	50	14	0.93	0.29, 2.98	0.97 [l]	0.30, 3.18 [l]
Missing	95		5		69				

Abbreviations: CI, confidence interval; MI, multiply imputed; NA, not applicable; OR, odds ratio. [a] Estimated via simple (unadjusted) unconditional logistic regression models. [b] The imputation model we used for multiple imputation included the 21 characteristics shown in this table and the five radon policy opinion questions shown in Table 2. We imputed 100 datasets. [c] Estimated via multivariable (adjusted) unconditional logistic regression models. [d] Adjusted for age, gender, and race/ethnic background using the versions of these variables shown in this table. [e] Adjusted for age and relationship status using the versions of these variables shown in this table. [f] Adjusted for age and race/ethnic background using the versions of these variables shown in this table. [g] Category boundaries set at the median of the distribution of this variable. [h] One participant reported being homeless. [i] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, and relationship status using the versions of these variables shown in this table. [j] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, and own or rent home using the versions of these variables shown in this table. [k] Number of questions answered correctly out of four. Derived from questions 1–4 (Supplemental Materials, Radon Testing Survey, p. 2), which were "What is radon?", "Which of the following is the major health concern caused by exposure to radon?", "What is the main way that radon enters your body?", and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?", respectively. Variable based on results from Davis et al. [30]. [l] Adjusted for age, highest grade or degree completed, and own or rent home using the versions of these variables shown in this table. [m] Means with possible values that ranged from one to five. [n] Derived from questions 7–9 (Supplemental Materials, Radon Testing Survey, p. 2), which were "At least one of my family members has encouraged me to test my home for radon", "At least one of my friends has encouraged me to test my home for radon", and "At least one of my neighbors has encouraged me to test my home for radon", respectively. Variable based on results from Davis et al. [30]. [o] Derived from questions 20–22 and 24 (Supplemental Materials, Radon Testing Survey, p. 2), which were "I do not know where to buy a radon testing kit", "I know who to contact to learn more about radon testing", "I know how to test my home for radon", and "I can find help to test my home for radon", respectively. Responses to question 20 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [p] Adjusted for age and highest grade or degree completed using the versions of these variables shown in this table. [q] Derived from questions 15, 16, and 19 (Supplemental Materials, Radon Testing Survey, p. 2), which were "It is important to me that I know if there are unseen health risks in my home", "It is important to me that I know the radon levels in my home", and "I am not worried about radon making me sick", respectively. Responses to question 19 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [r] Adjusted for highest grade or degree completed, relationship status, and radon knowledge using the versions of these variables shown in this table. [s] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, risk perception, and before today, ever tested current home for radon using the versions of these variables shown in this table. [t] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, and risk perception using the versions of these variables shown in this table. [u] Twenty participants were excluded from analyses of this variable because they answered "Not applicable".

Table 7. Unadjusted and adjusted, multiply imputed associations between characteristics and number of radon policy opinion questions (out of five) for which participants answered "Yes" among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

	Number of Radon Policy Opinion Questions (out of Five) for Which Participants Answered "Yes" (5 vs. 0–4)								
	5		0–4		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Age, years									
18–44	58	69	5	28	116	1.00	Reference	NA	NA
45 and above	26	31	13	72	86	0.52	0.28, 0.96	NA	NA
Missing	1		0		2				
Gender									
Male	29	35	14	78	85	1.00	Reference	NA	NA
Female	53	65	4	22	111	3.12	1.61, 6.05	NA	NA
Missing	3		0		8				
Race/ethnic background									
Caucasian	65	77	16	89	188	1.00	Reference	NA	NA
Asian, Pacific Islander, Black or African American, Hispanic/Latino, Native American, biracial, or other	19	23	2	11	13	1.88	0.63, 5.60	NA	NA
Missing	1		0		3				
Highest grade or degree completed									
Less than high school, some high school, high school or earned GED certificate, or some college	41	48	3	17	93	1.00	Reference	1.00	Reference
Bachelor's degree, Master's degree, some graduate, or professional/doctorate (e.g., MD, JD, PhD, DDS, etc.)	44	52	15	83	107	0.74	0.39, 1.40	0.91 [d]	0.46, 1.81 [d]
Missing	0		0		4				
Current annual family income									
Less than USD 15,000 to USD 64,999	54	64	2	11	114	2.04	1.08, 3.86	1.82 [e]	0.94, 3.52 [e]
USD 65,000 or greater	31	36	16	89	78	1.00	Reference	1.00	Reference
Missing	0		0		12				
Relationship status									
Currently married	59	70	15	83	163	1.00	Reference	1.00	Reference
Not married, living with partner; single, never been married and not living with a partner; separated; divorced; or widowed	25	30	3	17	34	1.44	0.63, 3.29	1.45 [f]	0.62, 3.39 [f]
Missing	1		0		7				

Table 7. *Cont.*

	Number of Radon Policy Opinion Questions (out of Five) for Which Participants Answered "Yes" (5 vs. 0–4)								
	5		0–4		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Number of people who live in home [g,h]									
0–4	57	67	11	61	143	1.00	Reference	1.00	Reference
5–10	28	33	7	39	55	0.93	0.49, 1.75	0.88 [i]	0.43, 1.83 [i]
Missing	0		0		6				
Number of children who live in home [g]									
0–1	47	55	9	50	109	1.00	Reference	1.00	Reference
2–6	38	45	9	50	89	0.73	0.41, 1.31	0.63 [i]	0.31, 1.31 [i]
Missing	0		0		6				
Own or rent home									
Own	55	65	18	100	127	1.00	Reference	1.00	Reference
Rent or other	30	35	0	0	72	1.34	0.66, 2.69	0.53 [i]	0.21, 1.36 [i]
Missing	0		0		5				
Type of residence live in									
Single-family home	57	67	17	94	135	1.00	Reference	1.00	Reference
Townhome or condominium, mobile home or manufactured home, basement apartment, first floor apartment, or second floor apartment or above	28	33	1	6	63	1.40	0.67, 2.94	0.92 [i]	0.40, 2.12 [i]
Missing	0		0		6				
How long lived in current residence, years [g]									
0–5	53	62	4	22	94	1.00	Reference	1.00	Reference
>5–55	32	38	14	78	104	0.68	0.36, 1.28	1.01 [j]	0.45, 2.27 [j]
Missing	0		0		6				
Radon knowledge, one question change [k]						0.76	0.53, 1.09	0.82 [l]	0.56, 1.22 [l]
Missing	47		12		165				
Behavioral modeling [g,m,n]									
1–2	42	50	11	61	130	1.00	Reference	1.00	Reference
3–5	42	50	7	39	71	2.03	1.01, 4.06	2.31 [l]	1.12, 4.74 [l]
Missing	1		0		3				

Table 7. *Cont.*

	Number of Radon Policy Opinion Questions (out of Five) for Which Participants Answered "Yes" (5 vs. 0–4)								
	5		0–4		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Self-efficacy, one unit change [m,o]						0.82	0.62, 1.08	0.95 [p]	0.69, 1.30 [p]
Missing	0		0		3				
Risk perception [g,m,q]									
1–4	36	42	11	61	146	1.00	Reference	1.00	Reference
5	49	58	7	39	54	1.99	1.02, 3.88	2.55 [r]	1.23, 5.29 [r]
Missing	0		0		4				
Study group									
Environmental Health	33	39	10	56	67	0.90	0.48, 1.69	3.33 [s]	0.95, 11.68 [s]
Vital Records	52	61	8	44	137	1.00	Reference	1.00	Reference
Before today, ever tested current home for radon									
No	78	94	14	78	170	1.00	Reference	1.00	Reference
Yes	5	6	4	22	20	0.37	0.15, 0.90	0.59 [t]	0.20, 1.75 [t]
Missing	2		0		14				
In the past year, heard about radon from any of the following									
TV, radio, newspaper, internet, friend, family member, Utah County Health Department, health care provider, other, or combination	59	71	16	89	130	0.99	0.49, 2.02	NA	NA
None	24	29	2	11	64	1.00	Reference	NA	NA
Missing	2		0		10				
Have at least one family member who tested their home for radon									
No	50	82	12	71	89	1.00	Reference	1.00	Reference
Yes	11	18	5	29	19	0.72	0.35, 1.48	0.73 [l]	0.34, 1.55 [l]
Missing	24		1		96				
Have at least one friend or neighbor who tested their home for radon									
No	27	61	9	60	46	1.00	Reference	1.00	Reference
Yes	17	39	6	40	37	1.29	0.63, 2.64	1.36 [l]	0.64, 2.92 [l]
Missing	41		3		121				

Table 7. *Cont.*

	Number of Radon Policy Opinion Questions (out of Five) for Which Participants Answered "Yes" (5 vs. 0–4)								
	5		0–4		Missing	Unadjusted [a], MI [b]		Adjusted [c], MI [b]	
Characteristic	***n***	**%**	***n***	**%**	***n***	**OR**	**95% CI**	**OR**	**95% CI**
Have at least one friend, family member, or neighbor who tested their home for radon and found radon levels in their home were high [u]									
No	22	59	8	62	36	1.00	Reference	1.00	Reference
Yes	15	41	5	38	32	1.01	0.46, 2.19	1.03 [l]	0.46, 2.33 [l]
Missing	43		5		121				

Abbreviations: CI, confidence interval; MI, multiply imputed; NA, not applicable; OR, odds ratio. [a] Estimated via simple (unadjusted) unconditional logistic regression models. [b] The imputation model we used for multiple imputation included the 21 characteristics shown in this table and the five radon policy opinion questions shown in Table 2. We imputed 100 datasets. [c] Estimated via multivariable (adjusted) unconditional logistic regression models. [d] Adjusted for age, gender, and race/ethnic background using the versions of these variables shown in this table. [e] Adjusted for age and relationship status using the versions of these variables shown in this table. [f] Adjusted for age and race/ethnic background using the versions of these variables shown in this table. [g] Category boundaries set at the median of the distribution of this variable. [h] One participant reported being homeless. [i] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, and relationship status using the versions of these variables shown in this table. [j] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, and own or rent home using the versions of these variables shown in this table. [k] Number of questions answered correctly out of four. Derived from questions 1–4 (Supplemental Materials, Radon Testing Survey, p. 2), which were "What is radon?", "Which of the following is the major health concern caused by exposure to radon?", "What is the main way that radon enters your body?", and "According to the U.S. Environmental Protection Agency (EPA), radon levels in your home should not be above what level?", respectively. Variable based on results from Davis et al. [30]. [l] Adjusted for age, highest grade or degree completed, and own or rent home using the versions of these variables shown in this table. [m] Means with possible values that ranged from one to five. [n] Derived from questions 7–9 (Supplemental Materials, Radon Testing Survey, p. 2), which were "At least one of my family members has encouraged me to test my home for radon", "At least one of my friends has encouraged me to test my home for radon", and "At least one of my neighbors has encouraged me to test my home for radon", respectively. Variable based on results from Davis et al. [30]. [o] Derived from questions 20–22 and 24 (Supplemental Materials, Radon Testing Survey, p. 2), which were "I do not know where to buy a radon testing kit", "I know who to contact to learn more about radon testing", "I know how to test my home for radon", and "I can find help to test my home for radon", respectively. Responses to question 20 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [p] Adjusted for age and highest grade or degree completed using the versions of these variables shown in this table. [q] Derived from questions 15, 16, and 19 (Supplemental Materials, Radon Testing Survey, p. 2), which were "It is important to me that I know if there are unseen health risks in my home", "It is important to me that I know the radon levels in my home", and "I am not worried about radon making me sick", respectively. Responses to question 19 were reverse coded because the question was negatively worded (i.e., 1, 2, 3, 4, and 5 were recoded as 5, 4, 3, 2, and 1, respectively). Variable based on results from Davis et al. [30]. [r] Adjusted for highest grade or degree completed, relationship status, and radon knowledge using the versions of these variables shown in this table. [s] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, risk perception, and before today, ever tested current home for radon using the versions of these variables shown in this table. [t] Adjusted for age, race/ethnic background, highest grade or degree completed, current annual family income, relationship status, own or rent home, radon knowledge, and risk perception using the versions of these variables shown in this table. [u] Twenty participants were excluded from analyses of this variable because they answered "Not applicable".

There was no statistical evidence for effect measure modification by study group (Environmental Health vs. Vital Records) of associations between radon knowledge, behavioral modeling, self-efficacy, or risk perception and opinions of radon policies (i.e., all multiply imputed Wald *p*-values were greater than 0.1; not shown).

Six key themes emerged from the thematic analysis of the open-ended response on how policymakers can expand radon awareness, testing, and remediation across the state (Table 8): (1) increase public education/awareness; (2) require testing in existing and new homes, schools, business, and public buildings, including the disclosure of radon levels through legislation and through policies involving building codes, permits, and real estate transactions; (3) increase access to testing through lower costs, free tests, advertisements, and increased funding and assistance; (4) identify radon hotspots and alert public; (5) continue with current efforts and strategies and/or no further recommendations; and finally (6) uncertainty and/or lack of knowledge about radon expressed as "No opinion"/"I don't know"/"I don't know what radon is"/"N/A"/"Not sure"/"No idea." Respondents highly favored increasing public education and awareness of radon using various information dissemination strategies more than legislative mandates pertinent to testing, disclosure, and mitigation. Although the Vital Records Group expressed greater support for expanding access to testing, they were uncertain on how their local and state policymakers could specifically improve radon testing and mitigation.

Table 8. Main themes for what policymakers should do to increase radon awareness, testing, and remediation among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

What Do You Think Your Local and State Policymakers Should Do to Increase Radon Awareness, Testing, and Remediation throughout the State?	*n* = 352 Codes	%
1. Increase public education and awareness on radon through:		
a. General public education	35	9.9
b. State or local government offices and funding	6	1.7
c. State and local health departments awareness campaigns	7	2.0
d. City council/town hall meetings	3	0.9
e. Broadcast media (TV, radio, news coverage, commercials, public media)	62	17.6
f. Print media (newspapers, mails, newsletters, flyers, mailers)	36	10.2
g. Social media (internet, online, websites)	19	5.4
h. Advertisements (public service announcements, billboards, celebrity spokespersons)	27	7.7
i. "Word of mouth" and door-to-door	2	0.6
j. Monthly utility bills and tax notices	4	1.1
k. Research (studies or surveys)	4	1.1
l. Public schools, fairs, expos, presentations, displays	13	3.7
m. Offices, businesses, real estate agents	2	0.6
n. Healthcare professionals—pediatricians, clinics, hospitals	6	1.7
2. Require testing and/or disclosure of radon levels		
a. Create laws or regulations on radon testing	10	2.8
b. Require builders to test for radon during construction, building inspection, before home purchase	14	4.0
c. Include testing in building codes, building permits, home purchase contracts, home loans	10	2.8
d. Require builders, sellers, realtors to disclose radon levels	6	1.7
e. Require regular testing in homes, new homes, schools, public buildings	9	2.6
3. Increase awareness and access to testing	21	6.0
4. Identify radon hotspots and notify public	5	1.4
5. Current efforts and strategies are sufficient	7	2.0
6. Uncertain/Lacks knowledge on radon	45	12.8

Note: Entries indicate the codes or recurring topics identified from each participant's response. A response may include more than one code or topic.

4. Discussion

4.1. Policy Perspectives on Radon Testing and Mitigation among Homeowners and Renters

Radon remains not only a public health threat but also a policy issue in Utah. Except for the radon mitigation certification law [40,41], Utah's radon laws are nonexistent. The state lacks policies on radon testing, mitigation, and disclosure during real estate transactions and there is not a specific regulation on radon as a health hazard in a way that is similar to lead and asbestos laws [40]. In addition, there is no stipulation in building codes or a construction standard for radon-resistant new homes nor to have a radon mitigation system as a basic residential feature versus a home upgrade [40,41]. Currently, neither homebuilders nor home sellers are required by law to test and disclose radon levels in new and pre-existing Utah homes.

The State of Utah relies on voluntary radon testing, reporting, and remediation. Although radon tests are conducted, it is not required during home construction, building inspection, home purchase, or after occupying a current residence. This may explain why our study showed that 99% of survey respondents in Utah County were unaware of any specific policy or resolution on radon testing and mitigation in the State. The deficit in radon legislation is in stark contrast to the elevated radon hazards presented by Utah's geological potential for which EPA has classified the whole state as Zone 1 or Zone 2 [22]. Geologic potential accounts for the factors that facilitate the release of radon indoors such as soil permeability, uranium, thorium, and radium deposits, and groundwater [40]. Although the state's geological landscape determines the potential for radon exposure, it is the quality of homes and their capacity to resist the entry of radon indoors that exerts an even more significant impact on an individual's or a family's exposure. Likewise, the paucity of radon policies reflects not only the lack of political will, but also the insensitivity to the economic and emotional costs of a lung cancer diagnosis and treatment [40], particularly for a state that continues to have lung cancer cases despite having the lowest smoking rate in the nation.

Utah has seen some changes in terms of radon support from the real estate and construction sectors. In 2014, radon was added in the Real Estate Due Diligence Checklist as a health hazard that must be considered when buying or selling a home in Utah [40,41]. In 2016, the Utah Construction Commission, with the support of the Utah Home Builders Association, voted to allow general contractors to install mitigation systems in new homes, which used to be performed only by licensed mitigators [41,42]. Though intended to promote and pre-empt radon-resistant new construction, the potential downsides include the lack of warranty since testing is not required after occupying a new home, the lowering of mitigation certification requirements, and the absence of a state standard on remediation systems. This also contradicts the State's mitigation certification law that requires professionals who perform radon remediation work to be licensed and nationally certified [41,42].

In spite of this policy headway, without legislative pressure and incentives for testing, mitigation, and disclosure of radon levels in new and pre-existing homes, statewide compliance in Utah is not guaranteed. Not every builder may include a radon mitigation system or test for radon. This leaves the public unprotected and the health of families at risk. In addition, the lack of legislative action could translate into the loss of funding leverage for economic assistance for homes needing radon corrective action, especially for low-income families and communities, and the loss of financial support for radon research.

4.2. Role of Policymakers in Increasing Radon Awareness, Testing, and Remediation

Participants in our study were asked about their views on various actions that local and state policymakers should do to heighten radon awareness, testing, and remediation (Table 8). Both the Environmental Health and Vital Records participants expected their policymakers to intensify public education and awareness efforts regarding radon. Although participants were more likely to express an expectation from their policymakers to offer public education than legislative mandates, both groups were similarly supportive of

radon policies on testing, disclosure, and mitigation during home construction, inspection, and purchase. As shown in Table 2, both groups expressed the need for state laws requiring testing and reporting of radon levels, particularly in schools (98%), followed by businesses (85%), and homes (81%). Majority (92%) are supportive of requiring radon-resistant features in new homes (92%) and incorporating radon testing and mitigation in building codes (89%), with home sellers (34%) having the primary responsibility for disclosing radon levels to potential homebuyers. Interestingly, more participants in the Vital Records Group articulated the need for expanding access to radon testing (Table 8). This could have stemmed from an assumption among participants in this group that testing costs were prohibitive without knowing that radon testing is relatively cheap. The Vital Records Group also voiced greater uncertainty regarding what to expect from their policymakers, which may stem from a knowledge deficit about radon (Table 8). It is possible that those respondents, who did not feel well-informed about radon and its health effects, may have been hesitant to suggest a legislative path to increase testing while also weighing the potential short- and long-term implications of such policies.

A key public health implication that is easily obscured from a policy context is the synergistic damage caused by smoking and radon. The combined effects of smoking and radon increases the risk of lung cancer much more than either exposure alone. Of the deaths from radon-induced lung cancer, 86% are in current and previous smokers [43]. Lantz, Mendez, and Philbert [43] made an emphatic call to action to integrate radon risk reduction policies and messaging with the tobacco cessation and lung cancer screening programs as a cost-effective public health measure. This could potentially reinvigorate policymakers' attention on radon reduction regulations in Utah. A "test, mitigate, and quit" public health message from a consolidated smoking cessation and residential radon control program is legislatively appealing, not only because it is needed and economical, but because it also offers the opportunity to geotarget current and former smokers in radon hotspots.

However, the reverse could also happen. It is possible that a consolidated strategy may not receive sufficient legislative backing as Utah has not only the lowest smoking rate but also the lowest cases of lung cancer and lung cancer deaths (16.4) in the nation vs. the national rate of 34.8 deaths per 100,000 [44]. By lung cancer incidence, Utah reported a 25.6 age-adjusted incidence rate per 100,000 population in 2016, which was approximately half the national rate of 56 per 100,000 population [45]. In terms of adult smoking rates, Utah has a 9% statewide average smoking rate compared to the national average of 14% in 2019 [46,47]. However, when the state average is disaggregated by counties, the EPA Zone 1 counties in Utah, which have the highest indoor levels of radon, are also the counties that reported the highest smoking levels among adults 18 and older, as compared to Utah County, an EPA Zone 2, which reported the lowest rate in the state at 4.1%. For Utah's seven EPA Zone 1 counties, adult smoking rates were comparatively elevated with Carbon at 23.1%, the highest in the state; Grand at 18.7%; Duchesne at 17.1%; Piute at 16.5%; Uintah at 15.4%; Sevier at 13.9%; and Sanpete at 11.9% [48].

Policies on radon preventive measures and remediation are cost-effective. Gray, Read, McGale, and Darby looked at the cost-effectiveness of radon policies in terms of preventing lung cancer deaths from indoor radon exposure, cost of remediation, and as complementary to smoking reduction policies [49]. They concluded that expanding the policy nationwide on requiring even basic radon-reduction features in all homes was more cost-effective than limiting it to only the new homes, and thus, should be incorporated in building regulations [49]. Additionally, their analyses showed that such policy could prevent a thousand deaths from lung cancer in 20 years of implementation [49]. This preventive measure remained cost-effective even when compared to the policy of requiring full remediation of existing homes only if indoor radon exceeded 200 Bq/m^3 (5.4 pCi/L), which is the action level in the U.K. [49]. Gray et al. contended that this action level-based policy on existing homes disregarded the fact that lifetime exposures to radon, even when below the action level, were still significantly associated with radon-induced lung cancer, especially among smokers [49]. Nevertheless, remediation measures were deemed cost-

effective, particularly among home residents who were current smokers, and would benefit current and future homeowners.

4.3. Bridging the Gap between Radon Awareness and Testing Behavior: Social Cognitive Constructs and Radon Policy Perspectives

Despite the dearth in radon policies, Utah has public education programs and awareness campaigns on radon that have been supported by the State Legislature [40,41]. In 2013–2015, funding appropriations were allocated for media and electronic campaigns to increase public awareness of radon. For instance, in 2013, the Substitute Concurrent Resolution on Radon Gas (SCR 11) authored by then Representative John Valentine, designated January 2014 as Utah State Radon Action Month to coincide with the National Radon Action Month [40,41]. Additionally, USD 25,000 was allocated for electronic media campaigns on radon and lung cancer [41]. Then again, no comprehensive legislative measure regarding radon testing, reporting, and mitigation has been brought forward since 2013.

Radon testing behavior in Utah remains low. Investments in radon awareness and public education have not translated into a widespread testing culture. Of the Utah County homeowners and renters surveyed in our study, 69% reported having heard about radon from broadcast, print, and social media including personal associations, health organizations, and healthcare providers. Nevertheless, when asked whether they have ever tested their homes for radon, 90% admitted to never having done so. The results of this study are similar to the findings of the 2013 Behavioral Risk Factor Surveillance System (BRFSS) Survey in Utah in which 80% have not ever tested their homes for radon [28]. Based on the BRFSS data, the top 5 reasons for not testing included: "haven't thought about it" (34.6%); "not at risk/not needed" (14.1%); "don't know what radon is" (13.3%); "don't own home/renting" (8.1%); and "house is new" (8.0%) [19]. Fifty-one percent of the BRFSS respondents knew that lung cancer was associated with radon [28]. However, 18.5%, believed that radon was associated with asthma and almost as many (17%) thought that it wasn't even associated with any health condition [28]. What was concerning was that despite investments in educational programs on radon, a substantial percentage of respondents (48.4%) remained unaware of the severity of the medical consequence of radon exposure, while others erroneously ascribed the effects of radon exposure to a different chronic disease [28].

There appears to be a gap in the translational pathway between radon knowledge and testing/mitigation behavior. In addition to a policy vacuum, the findings from the 2013 BRFSS survey and from our study suggest that there are intervening factors between radon awareness and testing that could either dampen or drive the trajectory towards testing. Although the use of the action-level approach (i.e., risks are negligible if action is taken to reduce risk to a certain level) in public health risk communication is straightforward and easy-to-understand for residents and homeowners, such approach does not account for the complex interactions of several determinants that influence the perception of risks, which has "context-specific" and "multidimensional" elements [50,51]. The context-specific aspect includes social norms such as "community, cultural and social values, and behaviors" while the multidimensional component is comprised of "cognitive and emotional responses" [51]. However, the dissemination of radon information focuses typically and inordinately on the cognitive/information aspect but neglects to incorporate the emotional and contextual elements of risk perception, which drive individual action. According to Adler and Pittle [52], the desired behavior is not dependent on "empirical knowledge," but largely on "philosophical and ideological factors" [52]. Hence, Johnson and Luken recommend that government programs identify and incorporate components that will positively impact the behavioral intent to voluntarily carry out radon protective measures, which would then translate radon information into an effective policy tool [50].

Behavior change theories provide the theoretical framework for examining the determinants of risk perception and health behavior [53], such as radon testing. In particular, the Social Cognitive Theory focuses on the dynamic and reciprocal influences of one's environment on behavior and on personal/cognitive factors [54]. One's social environment

shapes the individual inasmuch as the individual shapes his or her social environment. Through behavioral modeling and observational learning, one learns by watching, imitating, and modeling the behavior and attitudes of others, particularly those within one's immediate social network. Behavioral modeling motivates through social support, emotional encouragement, and verbal persuasion as one learns from others' actions. As new behavior is learned, both self- and collective efficacy are enhanced, which further reinforces the behavior. For instance, Davis et al. [30] examined the role of risk perception, behavioral modeling, self-efficacy, and radon knowledge on increased residential radon testing—all four of which were found to be positively associated with the desired behavior.

Policy perspectives and mitigation behavior are both influenced by risk perception. Johnson and Luken's study [50] on the perspectives of Maine homeowners showed that even when provided with objective risks to encourage voluntary radon mitigation, such as actual home radon levels, pamphlet material on radon health risks, and suggestions on reducing radon exposure, their perceived risks still significantly underestimated the objective health risks of radon. Weinstein, Klotz, and Sandman [55] found similar results among New Jersey residents. There was no statistically significant relationship between objective risks and increasing mitigating behavior [55]. Although improved radon knowledge may convince respondents of the seriousness of the health issue, the presence of "optimism bias" [55] led residents to significantly underestimate their own personal risks for radon, even when presented with radon facts.

To comprehend the knowledge-to-action gap from a policy context, our study examined the influence of demographic characteristics and social cognitive constructs on radon policy perspectives. Tables 3–7 list both unadjusted and adjusted associations between characteristics and opinions on policies regarding: (1) mandating testing and reporting of radon levels in homes and (2) businesses; (3) including testing and mitigation in building codes; (4) specifying the use of radon-resistant materials in building codes; and (5) the total number of affirmative responses to the questions on radon policy. Questions pertinent to behavioral modeling or observational learning, a social cognitive construct [54], inquired about having been encouraged by a family member, friend, or neighbor to test for radon. Questions on risk perception, a Health Belief Model construct [56], asked about the personal importance of unseen risks, radon levels at home, and having to worry about being sick from radon.

In terms of demographic characteristics, our study found a strong association between having pro-radon policy perspectives and being female, younger (18 to 44 years of age), and of a lower socioeconomic status (annual income of USD 15,000 to USD 64,999). The substantial association between being female and younger and answering affirmatively the policy questions on having laws mandating testing and mitigation could be explained by the influence of the social support network that behavioral modeling creates. In terms of social cognitive constructs, the higher the behavior modeling, the greater the likelihood of testing for radon and of answering "yes" to all five policy questions. Previous studies have shown that females typically have larger social networks [57], were more likely to share health information within their social networks [58], and were more likely to perceive radon as a health concern than men [59–61]. Thus, the strong association between being female, younger, and having pro-radon policy perspectives may be explained by the influence of the social support networks that favor behavioral modeling and a heightened perception of personal risk, which promotes a health-seeking behavior.

Conversely, being male, older (45 years and above), having a higher annual household income (USD 65,000 or greater), but lower behavior modeling and risk perception scores were less likely to be associated with radon testing behavior and answering "yes" to having radon policies. It is possible that being an older male and having a higher income underestimate the personal risks of radon. Risk perception is a factor of both the perceived susceptibility and perceived severity of threat [55]. Despite the common assumption in public health that heightened awareness of health risks will rationally result in increased precautionary action, and in the case of radon, improved testing and/or mitigation behavior,

there is actually a tendency to underestimate risks, or express optimism bias, especially the more the risk becomes personal than collective. This may explain why increased radon awareness, though positively related to increased perception of risk to the community, does not automatically result in personal testing and/or mitigation behavior. Misinterpretation of risk through optimism bias could be used to excuse inaction, particularly from an environmental threat, such as radon [55].

The findings of our study showed an increased likelihood of testing among those in the lower socioeconomic bracket. The pro-testing behavior among low-income individuals and families seen in our study counters the findings from several research on radon exposure and testing by socioeconomic status. Both smoking and radon are known to disproportionately affect the poor who are more likely to be financially challenged by the cost of mitigation [62,63]. Nevertheless, the motivation to test may be explained in part by renting or living in basements and/or by having landlords either subsidize or pay wholly for testing, particularly if required by law. This pro-radon policy stance may also come from the safety net provided by various organizations that provide radon mitigation assistance to low-income individuals, families, and communities. Weinstein, Klotz, and Sandman posited that the public tend to take risk seriously, even to the point of overreacting, when the accountability for mitigating the risk falls on others or on government entities rather than on themselves as homeowners [55]. However, further research needs to examine this specific demographic association.

Radon testing is a cancer prevention behavior. An accurate assessment of exposure while also emphasizing the social context of radon risk, especially within the context of risk behaviors such as smoking and poor testing compliance, could help prevent lung cancer. Where threat, such as radon-induced lung cancer, is perceived as "distal and uncertain," it could easily be downplayed or disregarded [51]. Radon information will lead to testing behavior if the other elements of risk perception, such as the emotional and social components, are addressed [31,51]. Since health risks or threats are shared experiences [51], individuals tend to gravitate toward their social networks, particularly those whom they trust. Having a family member, friend, or neighbor who models radon testing is predictive of future testing and support for pro-radon testing/mitigation policies. Thus, incorporating behavioral modeling and risk perception in radon prevention strategies enhances the progression from knowledge-to-action, that is, from radon awareness to radon testing. This would likely require shoring up educational and awareness efforts by targeting not only the individual but also the individual's immediate social network who could reinforce a radon testing behavior. This could also mean utilizing peer-to-peer mentoring to develop a cadre of highly motivated individuals, who are benefited by the positive feedback from group encouragement and from the experience of carrying out a cancer prevention behavior.

Future efforts to reduce the incidence of radon-related lung cancer in Utah should include the following initiatives: (1) advocating for legislative action on statewide radon testing, disclosure, mitigation, and the construction of radon-resistant homes; (2) collaborating with several disciplines, such as psychology, and building a statewide radon coalition involving public health, nonprofit organizations, radon mitigation professionals, health care institutions, researchers, and other stakeholders; (3) applying and evaluating theory-based interventions that target the motivational influences of one's social environment to promote the translation of radon knowledge into testing behavior; and (4) incorporating the social, emotional, and cognitive elements of risk perception and testing behavior in radon education programs.

The Iowa Radon Coalition (IRC), comprised of almost 100 stakeholders, may serve as a model program to build from. Since its inception in 2010, the IRC has worked to increase radon awareness, testing, and mitigation across Iowa, and has pursued policy interventions related to testing and mitigation. From 2009 to 2014, these efforts resulted in a 20% increase in radon testing, and a 108% increase in radon mitigations completed by certified contractors in Iowa [64].

Limitations of this study include a relatively small sample size, which may explain some wide confidence intervals that likely reduced power for detecting statistically significant associations between participants' characteristics and opinions of radon policies. The cross-sectional design may mean the results represent awareness and opinions of radon policies and associations between participants' characteristics and opinions of radon policies during a specific time (i.e., May 2014–January 2016). Thus, the results may not reflect changes in awareness and opinions of radon policies and associations between participants' characteristics and opinions of radon policies over time. Although associations between participants' characteristics and opinions of radon policies were adjusted for multiple potential confounders, bias from unmeasured confounders (e.g., political party affiliation or ideology, smoking status) could have affected some of the results. The convenience sample may mean results do not generalize to all Utah County residents or to other populations in Utah. The meanings of "I don't know" and "I am not interested in this issue" responses were unclear but including categories for those responses in analyses could be similar to including a missing data indicator variable, which has been shown to bias results [65]. Therefore, "I don't know" and "I am not interested in this issue" responses were recoded as missing values, and multiple imputation was used to impute all missing data in the variables used for analyses [33,34].

5. Conclusions

Utah's geological landscape renders the whole state vulnerable to indoor radon exposure and radon-induced lung cancer. Radon testing is a cancer prevention measure. As such, it is a health behavior matter. It is also a policy issue. However, radon testing remains low despite investments in public education and awareness campaigns. This stems not only from a gap in the translation of radon knowledge to action, but also from the lack of radon policies in the state.

Policies can shape individual and collective behavior. The paucity in radon policies creates a void in motivating individuals and families to test for radon in their homes. Homeowners and renters are supportive of public education programs and legislative action directed at reducing levels of radon in the home, schools, and businesses. They also support the installation of radon-resistant features in homes and the inclusion of radon testing policies and disclosure in building codes and during the construction, building inspection, and home buying process. To effectively increase radon awareness and testing across the state of Utah, public health measures need to consider exploring theory-based interventions in bridging the gap between radon knowledge and action. Multi-sectoral radon risk reduction programs could incorporate a social modeling component that reinforces behavioral modeling, risk perception, and social support in creating and sustaining a radon testing culture in Utah.

Supplementary Materials: The following are available online at https://www.mdpi.com/article/10.3390/atmos12081016/s1, Radon Testing Survey, p. 2; Additional Information Regarding Data Analyses, p. 10; Table S1. Potential confounders adjusted for in analyses of adjusted, multiply imputed associations between characteristics and opinions of radon policies among radon testing survey participants, Utah County, Utah, May 2014–January 2016.

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