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## Home is Where the Health is? Exploring Healthy Housing in Colorado

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### Introduction and Background

The home environment is commonly considered to be a place of safety and comfort for people. However harmful exposures can occur in the home and some Colorado populations have increased risk to these exposures. Unhealthy housing conditions from radon and secondhand smoke (SHS) exposures occur disproportionately within Colorado populations, resulting in health equity and environmental justice issues.

Both radon and SHS are known carcinogens and exposures to them are associated with poor lung health outcomes. Radon exposure is considered to be the second leading cause of lung cancer behind smoking and is the first leading cause among nonsmokers.<sup>1</sup> Secondhand smoke is the third leading cause of lung cancer<sup>1</sup> and is caused when nonsmokers are exposed to the complex mixture of 4,000 chemicals and over 50 known carcinogens produced during active smoking and released into the air.<sup>2</sup>

Radon is a naturally occurring gas that is produced from the radioactive decay of uranium.<sup>2</sup> Uranium is commonly found in soil and can produce radon which diffuses through cracks in the walls of buildings and homes. The predicted levels of indoor radon are consistently high across all of Colorado (see map in appendix). Nearly half (44.6%) of the 80,000+ household radon tests done in Colorado from 2008-2012 resulted in levels above the Environmental Protection Agency's (EPA) action limit.<sup>3</sup>

Several studies have shown a synergistic relationship between the effects of smoke and radon exposure; meaning lung cancer risk from radon exposure increases for current or former smokers.<sup>4,5</sup> The relationship of SHS and radon exposure are less researched but potentially impact a broader population of both smokers and nonsmokers, including children.

The science behind the health effects of these exposures is well researched, but the role of social determinants of health and these exposures in the home has not been well studied. This study aims to describe disparities related to healthy housing around radon and SHS exposures in the home.

## Methods

Data come from the Colorado Behavioral Risk Factor Surveillance System (BRFSS) at the Colorado Department of Public Health and Environment (CDPHE). The BRFSS is an ongoing, state-based telephone survey conducted by random-digit dialing of adults ages 18 years and older. The survey collects data on health-risk behaviors, chronic diseases and conditions, access to health care, and use of preventive health services and practices. Data from survey responses are weighted in order to represent the total Colorado population. Cell phones were added to the BRFSS sampling in 2011 to account for the increasing number of households without a landline telephone and to represent the population more accurately.

Data were analyzed by age, race/ethnicity, income and housing unit type. Other data come from the Colorado Environmental Public Health Tracking Network and CDPHE's Radon Program.

BRFSS questions about radon were asked in 2012 and used to calculate the data presented in this study. Radon knowledge was calculated from the responses to *Do you know what radon gas is?* Radon testing was determined from responses to the question *Has your household been tested for the presence of radon gas?* Respondents who answered that their homes had been tested were asked, *Were the radon levels in your household above the Environmental Protection Agency's recommended action level of 4 picocuries per liter?* Lastly, if respondents indicated that their levels were above the action level they were asked, *In response to a high radon result did you:*

- *Retest;*
- *Do a long-term test;*
- *Have a mitigation system installed;*
- *No longer go in the basement;*
- *Other;*
- *Nothing?*

BRFSS questions about secondhand smoke in the home and type of residence were asked in both 2011 and 2012. To calculate secondhand smoke in the home the following questions were used:

- *During the past 7 days, on how many days, that is, since [fill in date], on how many days did anyone smoke cigarettes, cigars, or pipes anywhere inside your home? and*
- *How often have you smelled tobacco smoke from someone else's smoking drifting into your home or into common spaces from nearby apartments or from outside?*

Responses for type of residence were categorized into *single family home* if they responded they lived in a single family home or *multi-unit housing* if they responded in an apartment, condominium, townhome, dorm, on-campus apartment, fraternity/sorority house, or visiting faculty housing.

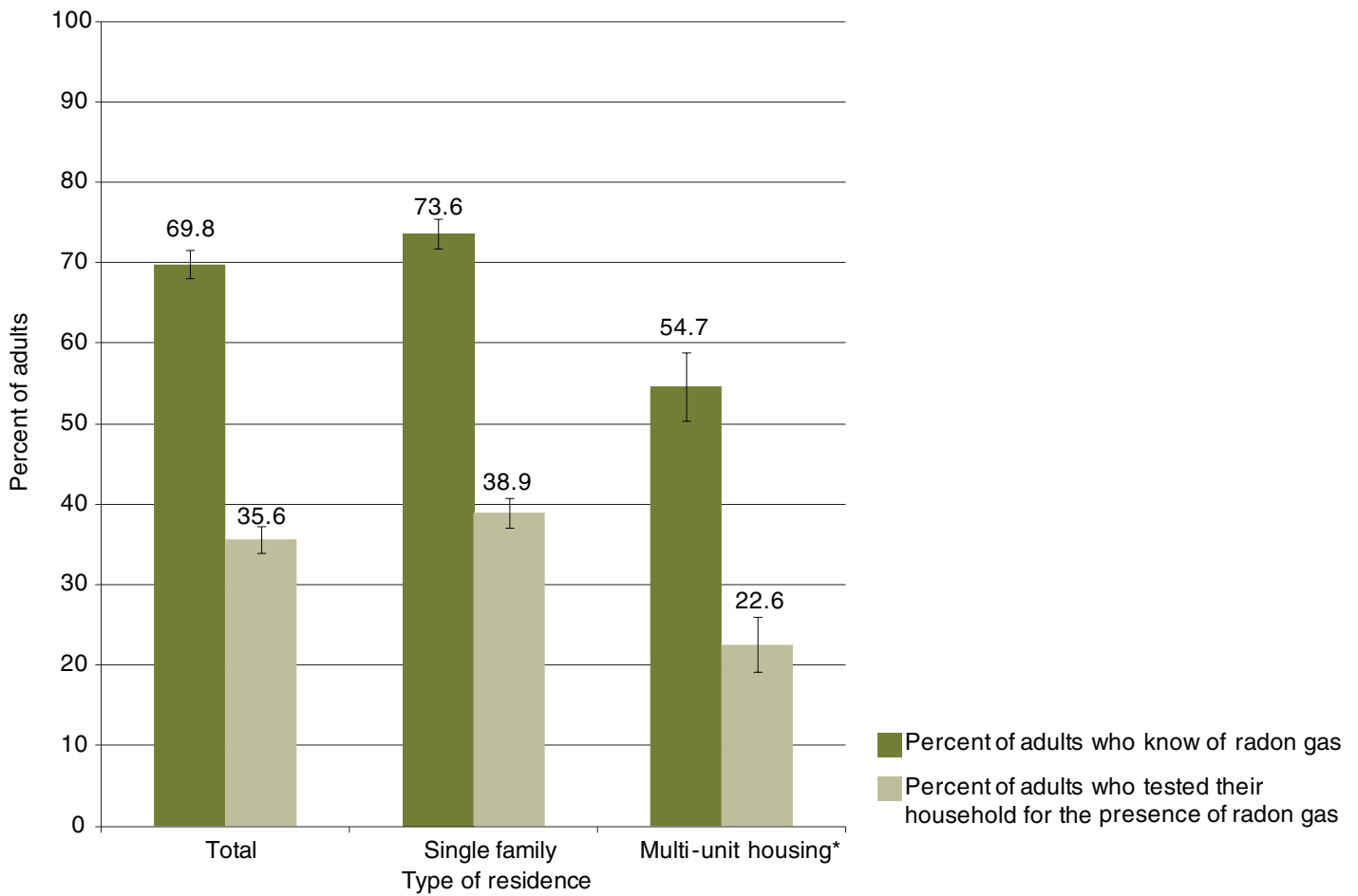
Differences in survey responses reported here are considered statistically significant if the confidence intervals of the associated percentages do not overlap, or the p-value of the comparison test is less than 0.05.

## Results

### ***Radon in the home***

Even though there is much research on the negative health effects of radon exposure, the dangers are not well understood by the population. Seventy percent (69.8%) of the total population knows of radon gas and 35.6 percent have tested their homes for radon. Around half of the adults reporting knowledge of radon gas are testing their homes for its presence. Adults living in single family homes (73.6%) are significantly more likely to have radon knowledge compared to the total whereas adults living in multi-unit homes (54.7%) are significantly less likely to know what radon gas is. Adults living in multi-unit housing (22.6%) are also significantly less likely to have their homes tested compared to adults living in single family homes (38.9%) (Figure 1).

Figure 1. Radon knowledge and testing by type of residence (2012).



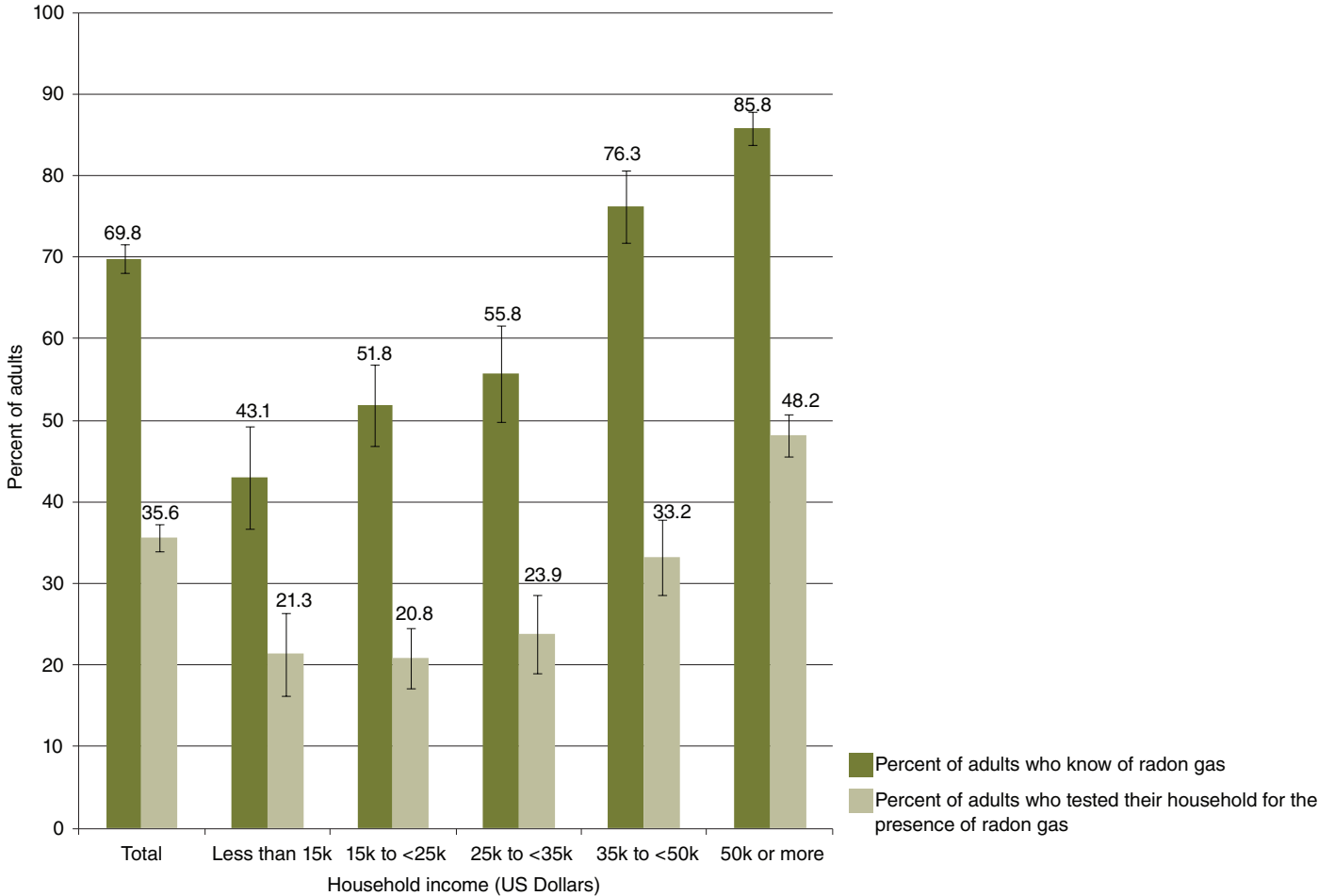
\*Multi-unit housing includes apartment, condo, townhome or dorm/campus apartment.

Error bars represent the 95% confidence intervals.

Source: Colorado BRFSS, Health Statistics Section, Colorado Department of Public Health & Environment.

There is a direct relationship between total household income and radon knowledge and testing. As household income increases so does the likelihood of radon knowledge and testing. Adults in households earning less than \$35,000 per year are significantly less likely to have radon knowledge and to have tested their homes for the presence of radon gas compared to the total population. Adults with incomes greater than \$50,000 per year are significantly more likely to have both radon knowledge and test their homes compared to the total (Figure 2).

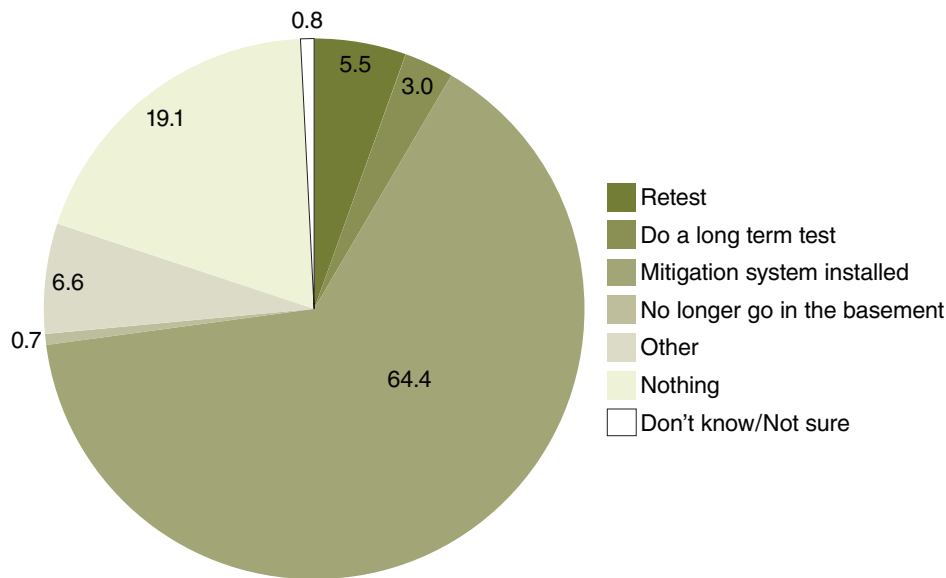
**Figure 2. Radon knowledge and testing by household income (2012).**



Error bars represent the 95% confidence intervals.  
 Source: Colorado BRFSS, Health Statistics Section, Colorado Department of Public Health & Environment.

Figure 3 shows the percent of adults who reported the levels were above the EPA limit after testing for radon, and the actions they took to address the elevated levels. The majority (64.4%) of adults reported installing a mitigation system while 19.1 percent reported doing nothing. Of the adults who had a mitigation system installed, 82.0 percent had a total household income of \$50,000 or more per year (data not shown).

**Figure 3. Percent of Colorado adults who tested for radon gas and levels were above EPA limit (4 pCi/L) by action taken (2012).**

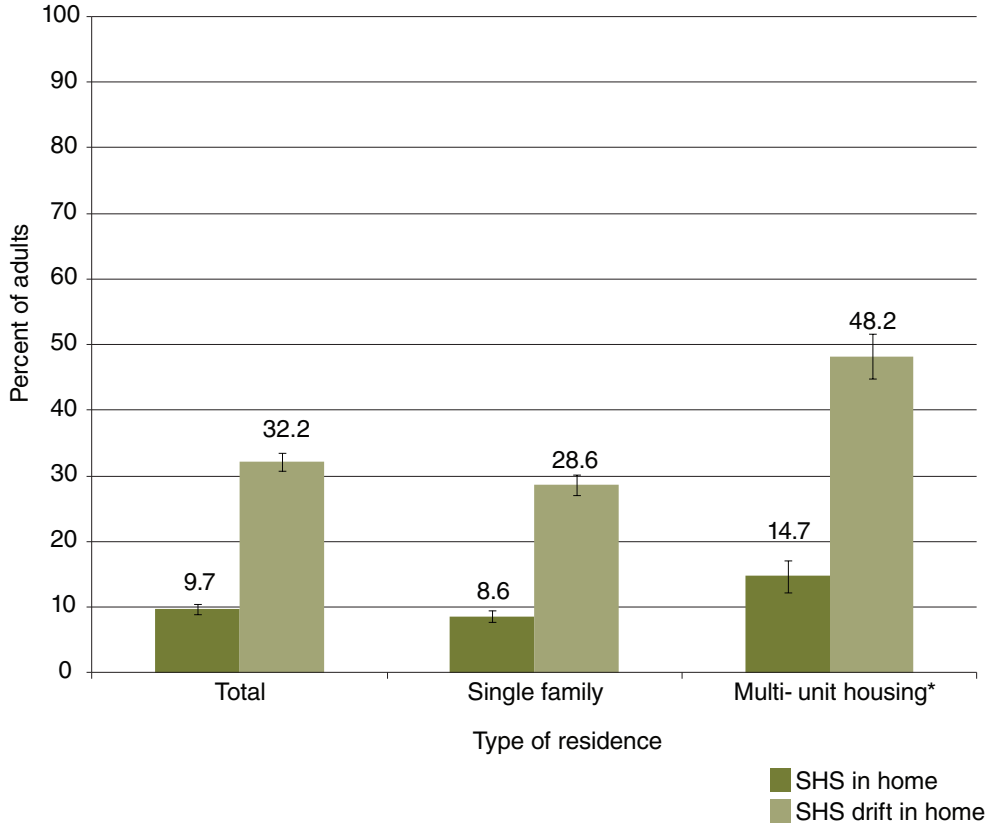


Source: Colorado BRFSS, Health Statistics Section, Colorado Department of Public Health & Environment.

### ***Secondhand smoke (SHS) in the home***

Nearly 10 percent of Colorado adults reported that someone else was smoking inside the home and 32.3 percent of adults reported that smoke had drifted into their home from outside. Adults living in multi-unit housing are significantly more likely to experience either type of SHS in the home compared to adults living in single family homes. Nearly half (48.2%) of adults in multi-unit housing experience SHS drift in the home (Figure 4).

Figure 4. Percent of Colorado adults who experienced any secondhand smoke in the home by type of residence (2011-2012).



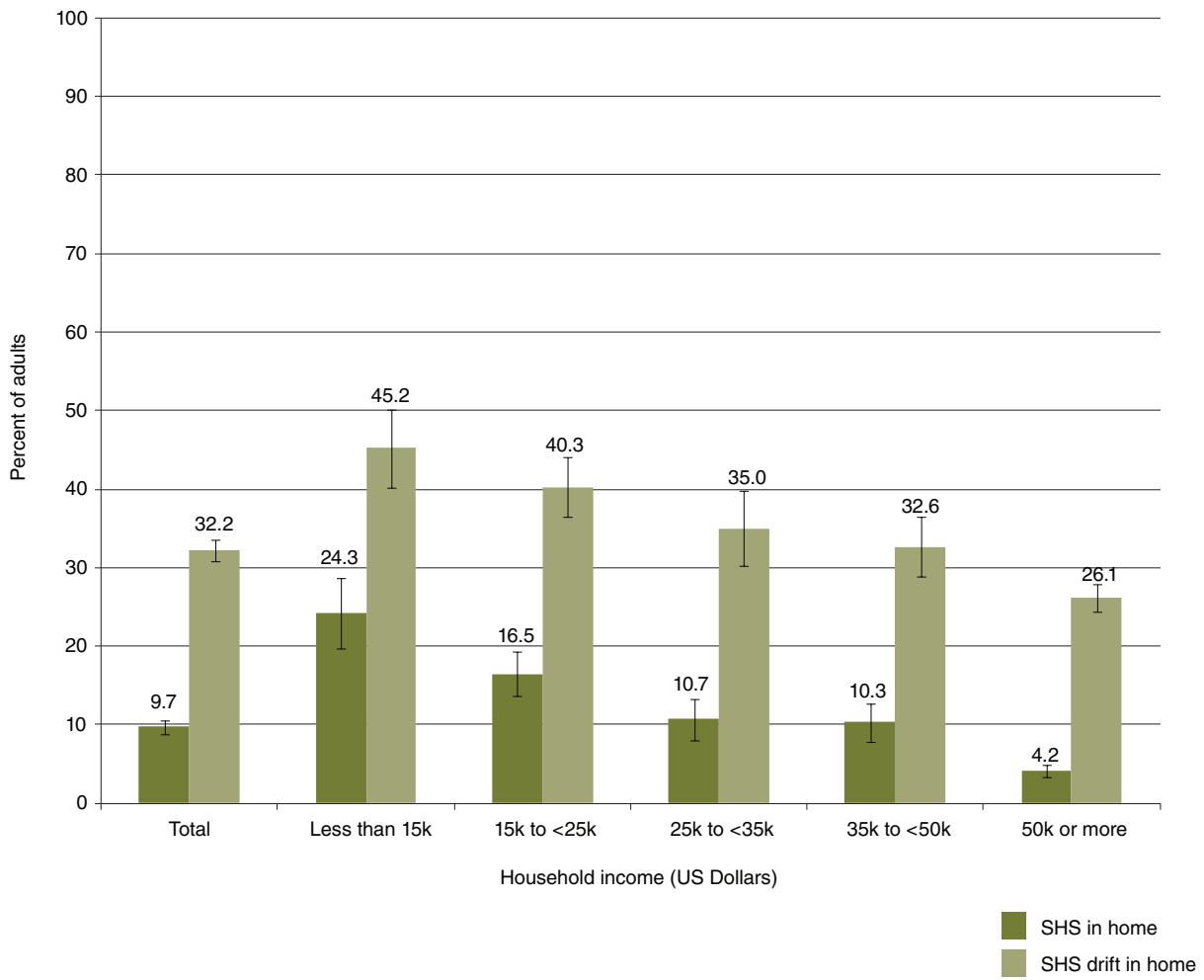
\*Multi-unit housing includes apartment, condo, townhome or dorm/campus apartment.

Error bars represent the 95% confidence intervals.

Source: Colorado BRFSS, Health Statistics Section, Colorado Department of Public Health & Environment.

Total household income is directly related to SHS exposure in the home. As income increases the likelihood of SHS exposure in the home significantly decreases. Forty-five percent (45.1%) of adults in homes earning less than \$15,000 per year experience SHS drift in the home compared to only 26.1 percent of adults with household incomes greater than \$50,000 per year. Households earning less than \$15,000 per year experience SHS by another person in the home, nearly six times more than households with incomes greater than \$50,000 annually.

Figure 5. Percent of Colorado adults who experienced any secondhand smoke in the home by household income (2011-2012).

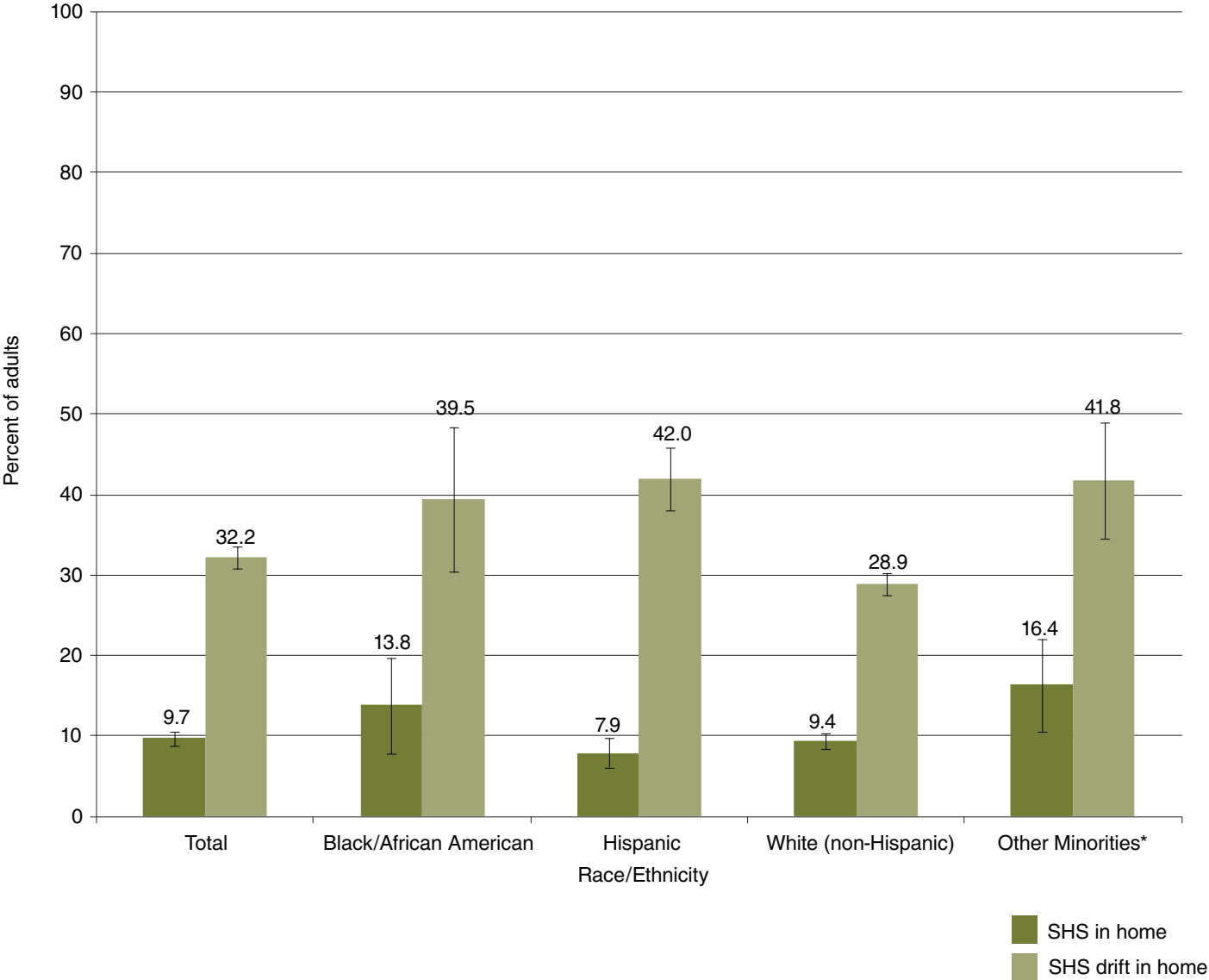


Error bars represent the 95% confidence intervals.

Source: Colorado BRFSS, Health Statistics Section, Colorado Department of Public Health & Environment.

Secondhand smoke exposures differ among some racial and ethnic groups. Hispanic (42.0%) and other minorities (including Asian/Pacific Islander and American Indian populations; 41.8%) experienced significantly greater SHS drift in the home compared to the total (32.3%). White, non-Hispanic adults (28.9%) experienced significantly less SHS drift in the home.

**Figure 6. Percent of Colorado adults who experienced any secondhand smoke in the home by race/ethnicity (2011-2012).**



\*Other minorities include Asian, Native Hawaiian or Other Pacific Islander, and American Indian or Alaska Native. Error bars represent the 95% confidence intervals. Source: Colorado BRFSS, Health Statistics Section, Colorado Department of Public Health & Environment.



## Discussion

The data demonstrate there are disparities among Coloradans related to secondhand smoke exposure and radon knowledge and testing. These disparities are contributing to health inequity and environmental injustice, particularly around healthy housing for all Colorado communities. Not only are many Coloradans unaware of the exposure risks like radon and SHS that may exist in their homes; there are a lack of policies to protect the home environment from potentially deadly exposures.

BRFSS data show that populations living in multi-unit housing, families with total incomes less than \$35,000 per year and minority populations are facing increased exposure to SHS in their homes as well as having less radon knowledge or testing. The need for further research and policy development are critical for addressing the needs of all Coloradans, especially where there are known disparities.

The synergistic effect of smoking status and radon exposure is well associated with poor lung health outcomes.<sup>4</sup> Further research is needed to demonstrate the relationship between SHS and radon exposure in the home. Lastly, more education around the health hazards of these household exposures is warranted to help all Coloradans have equitable and healthy housing environments.

## Limitations

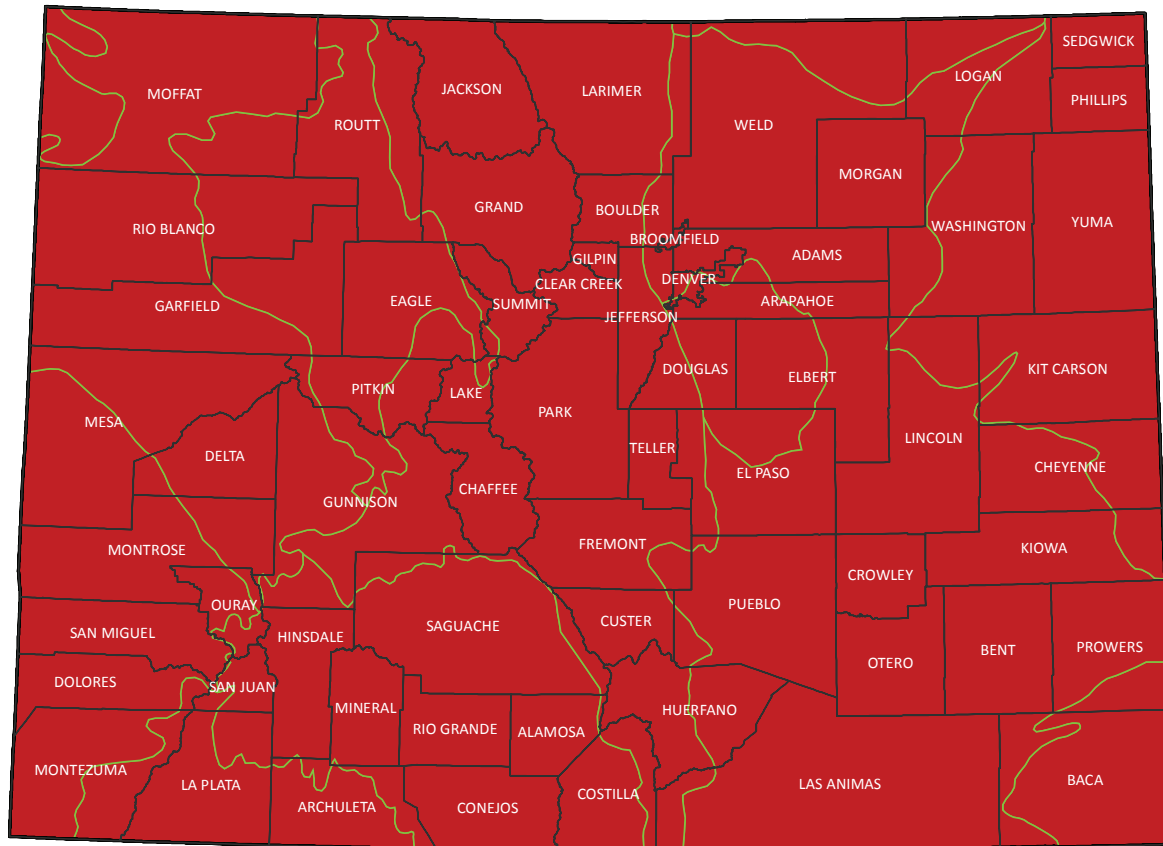
The data presented in this report are subject to the general limitations of survey data analysis and should be considered when interpreting. Survey responses are self-reported and susceptible to recall bias and social desirability. BRFSS survey data are limited by noncoverage of certain known populations: Institutionalized adults, households without a cell phone or landline or adults who do not speak English or Spanish. Survey data are also susceptible to nonsampling error which occurs when respondents interpret questions differently and errors in processing results or errors in the sampling frame.

Additional toxins that may exist in the home environment such as asbestos, lead, carbon monoxide and mold were not included in the BRFSS and therefore are not included in this report.

**Special thanks to the Colorado Healthy Housing Coalition, the Secondhand Smoke Initiatives Program, the Radon Safety Program and the Colorado Environmental Public Health Tracking Network for their expertise and support in writing this report.**

## Appendix

Figure A. Colorado Map of Radon Potential\*



### 2013 Radon Potential

High (>4 pCi/L)

\*Figure A adapted from the Environmental Protection Agency (EPA) and United States Geological Survey (USGS), shows radon potential in Colorado counties. Radon potential is defined as having an indoor air radon level over the EPA action limit of 4 pCi/L. Radon potential is determined based on a model that includes the bedrock geology, soil characteristics, construction types, aerial radiation measurements, literature review and indoor radon testing. Assuming that all of these inputs remain fairly constant except for the availability of indoor radon testing results the original model was augmented with more robust and current data. The original 1218 samples taken from 48 of Colorado's 64 counties were replaced with approximately 20,000 pre-mitigation samples collected from all 64 counties in 2011 and 2012.

The original EPA model predicts average radon levels above the EPA action level of 4 picocuries per liter (pCi/L) for all but 12 of the 64 counties in Colorado. Running the same model in 2013 using more robust data predicts average radon levels above the EPA action limit of 4 pCi/L for all of Colorado's 64 counties.

### Work Cited

1. United States Environmental Protection Agency. Radon Health Risks. Accessed from <http://www.epa.gov/radon/healthrisks.html>.
2. American Cancer Society. Cancer Facts & Figures 2006. Accessed from <http://www.cancer.org/acs/groups/content/@nho/documents/document/caff2006pwsecuredpdf.pdf>.
3. Colorado Department of Public Health and Environment, Hazardous Materials and Waste Management Division, Radon Program. Denver, CO.
4. United States Environmental Protection Agency. EPA Assessment of Risks from Radon in Homes. Accessed from <http://www.epa.gov/radiation/docs/assessment/402-r-03-003.pdf>.
5. Lantz PM; Mendez D; Philbert MA. Radon, Smoking, and Lung Cancer: The Need to Refocus Radon Control Policy. American Journal of Public Health 2013; 103(3):443-447.