PUBLIC HEALTH POLICY FOR TESTING OF RADON

IN MONTANA SCHOOLS

by

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A professional project submitted in partial fulfillment
of the requirements for the degree

of

Master

of

Nursing

MONTANA STATE UNIVERSITY
Bozeman, Montana

April 2014

DEDICATION

This professional project, and the work, tears, and time that have gone into the completion of it, is dedicated to my children in the hopes that they will have safe schools in Montana to attend that are free from the fear of radon exposure and the subsequent health effects.

ACKNOWLEDGEMENTS

First I would like to acknowledge my husband, Daniel, for his constant loving support, encouragement, and sacrifices that he has shown as I have embarked on this endeavor called graduate school. Without you by my side I would not have accomplished this dream.

I would especially like to acknowledge Dr. Laura Larsson for her patience, excitement, and contributions to the completion of this project. Dr. Larsson's passion for radon research and public health has ignited my own passion for public health and helped me to envision my role and involvement as an APRN in the community. Thank you for your time in chairing my graduate committee, the many edits you have reviewed, and the multitude of conversations helping me streamline my thoughts. I would also like to thank my committee members, Wade Hill, PhD, APRN BC, and Janice Hausauer MS, FNP BC for their efforts to ensure this project is complete, competent, and correct.

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ABSTRACT

Radon as a human carcinogen has been clearly documented (NTP, 2011; NCI, 2011; ATSDR, 2013; EPA, 2013). Radon is the second leading cause of lung cancer after smoking (NCI, 2011) and is found in every state in the U.S. (DEQ, 2013). As Hill, Butterfield, & Larsson (2006) have stated, children are a vulnerable population with consideration to radon exposure due to biophysical characteristics and duration and levels of exposure over time. As a nation responsible for its vulnerable youth, further investigation is necessary to determine that health policies exist to protect school children from this known carcinogen. This study inventoried the public health policies that exist at a federal, state, and local level and then compared and contrasted those policies for best practices. Results of the policy inventory were that nine states had state laws mandating radon testing in the schools. The Environmental Protection Agency zone risk designation demonstrated that 36 states had greater than 50% of counties in zones 1 and 2 (moderate to high risk for radon exposure) but only eight of those states had health policies for testing radon in schools. An analysis of the policies was conducted to identify best practices and a recommendation for a public health policy governing the testing of radon in Montana schools was developed. Research implications are that radon is a public health threat for which the regulatory environment to protect vulnerable children is lacking. The need for well written policy is evident and as states consider public health initiatives, radon testing in schools should be included in that discussion.

CHAPTER 1

INTRODUCTION

Introduction

Based on a nationwide survey, the Environmental Protection Agency (EPA) estimated that children in more than 70,000 classrooms nationwide are at risk for radon exposure with one in five classrooms in use above the recommended action level (2010). Next to smoking, radon exposure is the leading cause of lung cancer (NCI, 2011) and is a known human carcinogen (NTP, 2011; NCI, 2011; ATSDR, 2013; EPA, 2013). Bill Field, one of the foremost experts on radon, stated that of all the environmental exposures, radon is the one that causes the most deaths (Rossen Reports, 2012). Field compared a student's exposure to radon, even at the EPA's action level, 4 pCi/L, as equivalent to smoking half a pack of cigarettes per day (Rossen Reports, 2012). Children are a vulnerable population that are at increased risk for negative effects of radon exposure because of their increased respiratory rate, increased contact with the ground and greater cell division with growth (Hill, Butterfield, & Larsson, 2006; Dunn, Burns, & Sattler, 2003; Schneider & Freeman, 2000).

Radon is dangerous when it seeps into enclosed buildings and is inhaled by human occupants. Prolonged radon exposure is harmful to the lungs and may cause cancer. The mechanism of radon exposure and subsequent "cellular damage is not from radon gas itself, which is removed from the lungs by exhalation, but from radon's short-lived decay products" (University of Minnesota, 2013, "Specific genetic damage caused by radon”). Once inhaled, the alpha particles from radon decay products are deposited in the airways and lungs and continue to emit more alpha particles as the decay progeny are broken down further. Alpha particles are massive and highly charged and cannot travel very deep into the tissues, ultimately lodging themselves into the airways. Over time, the alpha particles break down the nucleus of the healthy lung tissue causing transformations, mutations, and displacements of cellular growth (University of Minnesota, 2013).

Cancer is a consequence of long term, low dose indoor exposure (EPA, 2013). The effects of radon are cumulative; therefore assessing lifetime radon exposures in the places where we live, work, and study is indicated. Because school children spend the majority of their time in a school building, the primary aim of this project was to determine if there are protective health policies in place to ensure safe school buildings that are free from long term radon exposure.

During an interview with Mr. Darrick Turner of the Montana Department of Environmental Quality, Mr. Turner explained that Montana does not have a school radon testing policy. He stated, “There is little oversight of institutions” and that “if schools do test, the results stay internal.” Turner also stated that it is a “foregone conclusion that school children are exposed” but he hopes that schools are “well vented because of all the doors opening and closing” (personal communication, December 2012).

Mr. Kevin Barre, the maintenance manager of the Bozeman School District stated he did test for radon in the school. During an interview, Mr. Barre stated “it was a personal decision in response to Montana State University recently receiving grants for radon education” that influenced his decision to test. “[He] figured people would be asking if they [Bozeman public schools] tested, and rather than not know, [he] decided to test. There was no policy that mandated the testing" and Mr. Barre felt that it was the "individual school policy to provide safe facilities for kids", although nothing specific about radon is written in the policy (personal communication, December 2012).

Statement of the Problem

Radon has been clearly documented as a human carcinogen (NTP, 2011; NCI, 2011; ATSDR, 2013; EPA, 2013). Radon is the second leading cause of lung cancer after smoking (NCI, 2011) and is found in every state in the U.S. (DEQ, 2013). As Hill, Butterfield, and Larsson (2006) have stated, children are a vulnerable population with consideration to radon exposure due to biophysical characteristics and duration and levels of exposure over time. As a nation responsible for its vulnerable youth, further investigation is necessary to determine if health policies exist to protect school children from this known carcinogen.

Purpose of the Study

The purposes of this study were three-fold: 1) to inventory and analyze the regulatory policies addressing indoor radon exposure in public buildings, 2) to compare and contrast existing policies for protecting school children from radon exposure, and 3) to prepare a best practice policy for presentation to the Montana State Attorney General and to state nursing organizations.

Research Questions

1. What are the current policies for administrative, constitutional, and statutory laws for testing radon in public schools in the U.S?

2. What is the best practice for testing radon in public schools based on current policies?

Significance to Nursing

The Advanced Practice Registered Nurse (APRN), like every nurse, acts as an agent of change in health promotion and disease prevention. “When examining the sources of environmental health risks in communities and planning intervention strategies, it is important to apply basic principles of disease prevention” (Sattler, McPhaul, Afzal, & Mood, 2004, p. 237). Basic principles of disease prevention include acknowledging known health risks and implementing behaviors that protect populations from exposure to that risk.

The established relationship between radon exposure and lung cancer is a risk relationship of concern, indicating the need for APRN involvement. As an APRN, it is necessary to investigate the primary prevention policies that are in place in order to educate patients about recommended steps for mitigating disease risk. As a nurse, it is also necessary to review the primary prevention policies that exist in terms of best practice and advocate for change when necessary in order to protect vulnerable populations.

Organization of the Remainder of the Study

In the next chapter, current and relevant literature is examined to establish the known relationship between radon exposure and the incidence of lung cancer. The development of public policy and advocacy methods are also briefly reviewed. In chapter three, the methods used to inventory current public health policy are discussed. In chapter four, the results of the inventory as applicable to this study are presented. In chapter five, the findings of this professional project are discussed and recommendations are given as they relate to this and further research, including a public policy proposal based on best practices.

CHAPTER 2

LITERATURE REVIEW

Introduction

Radon exposure over prolonged periods of time is a potential threat to developing lung cancer. Other than their homes, children spend most of their time in a school building, which is a potential source for radon exposure. School aged children are a vulnerable population based on biophysical processes and age. In order to effectively communicate the health risks associated with radon exposure in school buildings, it is necessary to find out what is already known about radon, its health effects, Montana's geographical risk, and public health policies as they relate to preventable radon exposures. In this chapter, current and relevant research was examined to help lay a foundation that will guide the remainder of the project.

Description of Literature Search

A review of the literature was conducted through the Montana State University library internet access portal. The search engines utilized were CINAHL and PubMed. The broad based internet search engine Google was also utilized in identifying public health organization websites such as National Cancer Institute (NCI), Environmental Protection Agency (EPA), Department of Environmental Quality (DEQ), and Agency for Toxic Substances and Disease Registry (ATSDR). Key word searches included "radon", “public health policy”, “lung cancer”, “health effects of radon”, “school children” and “Montana”.

What is Radon?

Definition

Radon is a naturally occurring radioactive gas that is odorless, colorless, and tasteless. Radon gas is formed during the decay of uranium, which is found in most rocks, soil, and water in all fifty states across America (DEQ, 2013). Radon itself also undergoes radioactive decay, with a half-life of about four days (DEQ, 2013). Radon radioactive decay divides into two parts, radiation and a daughter (progeny). The progeny parts are not gases and can attach to dust and other particles, which can then be transported by air and inhaled (DEQ, 2013). The daughter part is not stable and continues to divide into more radiation and another daughter until a stable, nonradioactive daughter part is all that remains. During each step of this dividing decay process, alpha, beta, and gamma radiation are released. Alpha particles are the most concerning in terms of radon health consequences. Alpha particles are large, highly charged particles that lodge into the airways and lung tissue. The alpha particles have the capability of causing DNA mutations and transformations, ultimately leading to abnormal cell growth and function (University of Minnesota, 2013).

EPA studies have found that average outdoor radon concentrations are about 0.4 pCi/L (EPA, 1993). Radon gas, and its byproducts, enters buildings through cracks in the foundation, construction joints, and around pipes, wires, or pumps and can ultimately build up to much higher concentrations inside of the building (Hill, Butterfield, & Larsson, 2006).

Health Effects of Radon

The health effects of radon as a human carcinogen are well documented by the National Toxicology Program, Report on Carcinogens, Twelfth edition (2011). The Report on Carcinogens is a “congressionally mandated, science-based, public health report that identifies agents, substances, mixtures, or exposures (collectively called "substances") in our environment that may potentially put people in the United States at increased risk for cancer” (NTP, 2013). The U.S. Surgeon General Richard H. Carmona released a national health advisory on January 13, 2005, warning the American public about the dangers of breathing radon gas in relationship to the development of lung cancer (USDHHS, 2005).

Radon as a carcinogen targets the respiratory system, specifically from the nose to the lungs (ATSDR, 2013) and is the second leading cause of lung cancer after smoking (DEQ, 2013). The National Cancer Institute estimates that radon causes about 15,000 to 22,000 lung cancer deaths in the U.S. each year (2011). The mechanism of injury is that the inhaled radon gas particles release small bursts of energy (radiation) as they decay that can damage lung tissue and lead to cancer (DEQ, 2013).

There is a direct correlation of lung cancer development based on three factors: the duration of radon exposure, the levels of radon exposure, and an individual’s smoking habits (EPA, 1993; Field, 2001; Field et al., 2000). The longer a person is exposed to higher levels of radon, increases the probability of developing lung cancer. If a person smokes, in addition to high levels and long duration of radon exposure, their risk of lung cancer is much greater than those who do not smoke.

Low Dose Residential Exposure

Studies have indicated that long term, low dose exposure to radon is the mechanism for cancer development as opposed to short term, high dose exposure (Krewski & Lubin 2005, 2006). Krewski and Lubin (2005, p.137) have examined case control studies in North America that demonstrated "direct evidence of an association between residential radon and lung cancer risk, a finding predicted using miner data and consistent with results from animal and in vitro studies".

Radon Zones

The EPA's Map of Radon Zones (see Figure 1) categorizes each of the 3,141 counties in the Unites States into one of three zones (EPA, 2012). The map was created using five factors to determine radon potential: 1) indoor radon measurements, 2) geology, 3) aerial radioactivity, 4) soil permeability, and 5) foundation type. Zone one, indicated by the red color, predicts an average indoor radon level above 4 pCi/L and has the highest potential for radon exposure. Zone two, indicated by the orange color, predicts an average indoor radon level between 2 and 4 pCi/L and has a moderate potential for radon exposure. Zone three, indicated by the yellow color, predicts an average indoor radon level below 2 pCi/L and has a low potential for radon exposure.

Figure 1. EPA Map of Radon Zones. Image retrieved from EPA (2012).

Radon in Montana

Few (12.5%) of Montana's counties are considered zone two (indicated by yellow on Figure 2), meaning they have a predicted average indoor radon screening level between 2 and 4 pCi/L. The remaining (87.5%) Montana counties are zone one (indicated by red on Figure 2), indicating that they have a predicted average indoor radon screening level greater than 4 pCi/L (DEQ, 2013). None of Montana counties are in zone three.

Mike Vogel, Montana State University Extension housing specialist, conducted a study for the Montana Department of Environmental Quality, in cooperation with the American Lung Association of Montana, which found that, "virtually all Montana counties with over 150 tests had between 28 and 65 percent of those tests show more radon than the EPA action level" (1997). The national average indoor radon level is 1.3

pCi/L, but in Montana the average is 5.9 pCi/L.(Vogel, 2013). These findings support the EPA zone designations.

Per a review of the literature using Lexis Nexis database, Montana does not have a federal, state, or local mandate that regulates the testing of radon in public school buildings. Assessment of the absence of a school radon policy in combination with the current radon risk environment in Montana indicates APRN involvement in policy recommendations.

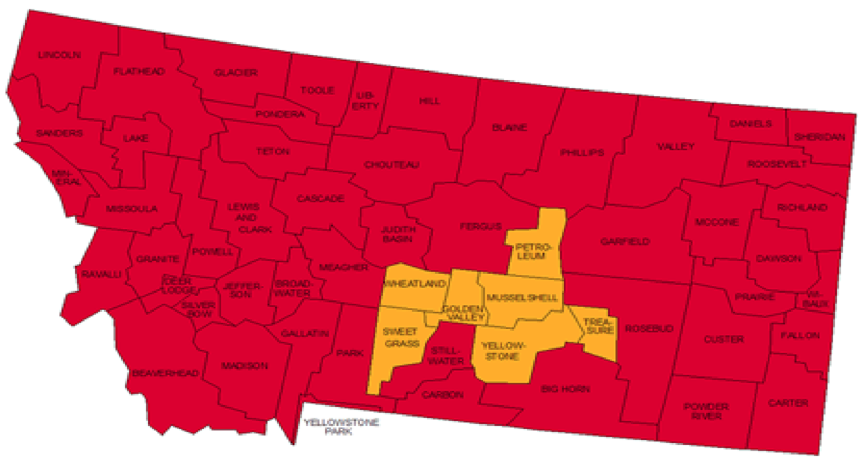

Figure 2. Montana County Radon Map. Image retrieved from EPA (2012).

<u>Montana Schools</u>

Based on the review of literature, it can be concluded that there are geographical risks of living in Montana in terms of lung cancer related to radon exposure (Vogel, 1997; Vogel, 2013). Additionally, numerous studies correlate duration, level of radon and risk of lung cancer (EPA, 1993; Field, 2001; Field et al., 2000). Hill, Butterfield, and Larsson (2006, p.392-392) documented that “children possess different physiologic, behavioral, and biologic capacities than adults; health risks resulting from exposure may be more severe (Dunn, Burns, & Sattler, 2003). Although children share the same routes of exposure with adults, children are at a distinct disadvantage for health consequences from environmental exposures (Schneider & Freeman, 2000). When adjusted for size, children have a greater body surface area, breathe more air, consume more food and fluids, and metabolize toxins differently than adults". Based on this information, one can posit that Montana children who sit in classrooms above the EPA recommended action level for an average of thirteen years are at an increased risk of developing radon exposure related lung cancer.

Current Recommendations for Radon Testing and Mitigation in Schools

The Environmental Protection Agency has developed recommendations for radon testing and mitigation in schools (1993). The EPA (1993, p.4) stated that for

> "most school children and staff, the second largest contributor to their radon exposure is likely to be their school. As a result, EPA recommends that school buildings as well as homes be tested for radon. EPA recommends reducing the concentration of radon in the air within a school building to below EPA's radon action level of 4 pCi/L. EPA believes that any radon exposure carries some risk - no level of radon is safe. Even radon levels below 4 pCi/L pose some risk, and the risk of lung cancer can be reduced by lowering radon levels. This action level is based largely on the ability of current technologies to reduce elevated radon levels below 4 pCi/L".

Testing with certified devices is the only way to determine whether or not the radon concentration is below the action level. Measuring levels of radon gas in schools is a relatively easy and inexpensive process compared to many other important building upkeep activities (EPA, 1993). Because radon levels in schools have been found to vary significantly from room to room, schools should test all frequently occupied rooms in contact with the ground such as cafeterias, gymnasiums, staff lounge, and classrooms.

Testing should be completed at a time when the air handling system is at normal school-hour settings to prevent false positive results. If a room is found to have a level of 4 pCi/L or greater, this measurement result should be confirmed with another test. If the second test is also at or above 4 pCi/L, schools should take action to reduce the radon level to below 4 pCi/L (EPA, 1993).

Theoretical Framework

The World Health Organization Multiple Exposures Multiple Effects (MEME) model was used as the theoretical framework for this professional project. The MEME model was originally developed by the World Health Organization, "through a participatory process, to provide a framework to children's environmental health indicators" (World Health Organization, 2013, para. 1). This model is very useful to guide the conceptual framework for this project because it is based on the collection and use of children's environmental health indicators. This model "emphasizes the complex relationships between environmental exposures and child health outcomes. Individual exposures can lead to many different health outcomes; specific health outcomes can be attributed to many different exposures" (World Health Organization, 2013, para.2). The MEME model examines both exposures and health outcomes, in addition to the associations between them, in terms of contextual conditions such as social, economic or demographic factors (World Health Organization, 2013).

The MEME model uses four components to monitor children's environmental health: exposure, health outcome, action, and contexts (population). It can be posited that this model can be superimposed on populations, not just individuals. The MEME model can be used to guide action that can be targeted at reducing exposures or at reducing the severity of health outcomes (World Health Organization, 2013, para. 3). The MEME model (see Figure 3), provided a concise and research-based framework to justify the policy inventory of radon testing in schools and subsequent policy recommendations (action) for school children's (context) exposure to radon (exposure) and the subsequent potential for lung cancer development (health outcome). The MEME model was the theoretical framework used in this project to complete the policy proposal and to form the recommendations discussed in chapter five of this project.

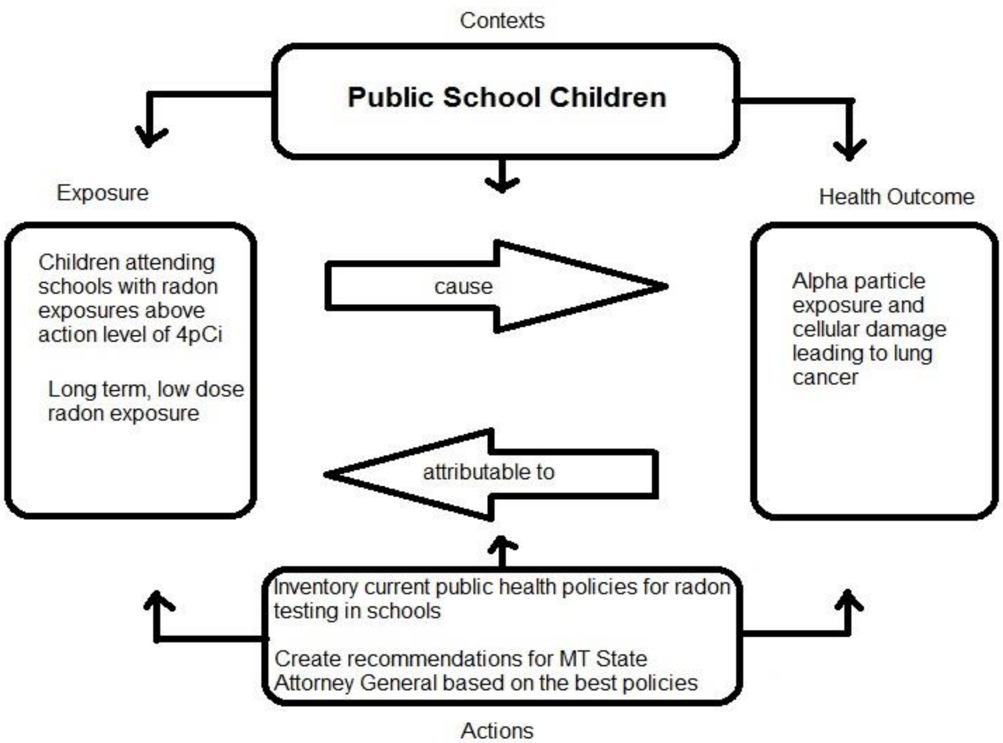

Figure 3. MEME Model. (World Health Organization, 2013).

Public Health Policy

Definition of Public Health Policy

Public health policies influence entire populations rather than individuals in terms of health prevention and promotion interventions as defined by the Association of Schools of Public Health (2013). The University of Kansas has created a Community Tool Box (2013) to guide in the creation of public health policies. The Community Tool Box (University of Kansas, 2013) consists of thirteen steps for effective policy development, of which the most appropriate were utilized in the proposed policy recommendations for this project as discussed in chapter five. In addition to The Community Tool Box (University of Kansas, 2013), the Multiple Exposures Multiple Effects (MEME) model (World Health Organization, 2013) was influential as a theoretical framework in the best practices recommendation for policy development based on its components of contextual conditions such as social, political, economic or demographic factors.

Advocacy Methods

Successful implementation of public health policy is best achieved through the use of advocacy methods. One advocacy method that is an “unrecognized political force” is the state attorneys general (Rutkow & Teret, 2010). State attorneys general are frequently called upon to give advice to the governor and administrative agencies and give an “issuance of opinions”, which can impact policy and promote change (Rutkow & Teret, 2010, p.8). State attorneys generals utilize “press releases, interviews, and press conferences” to engage in advocacy. State attorneys generals can also “raise awareness about topics by using his or her ability to convene individuals (Rutkow & Teret, 2010, p.9). Rutkow and Teret (2010) documented the increasing support over the past two decades that state attorneys general have provided to health care through policy reform work. An example of their supportive role is the 1998 Master Settlement Agreement against the tobacco industry (Rutkow & Teret, 2010).

Another advocacy method is the grassroots method. Grassroots advocacy encourages the public to advocate for themselves and the "value of this form of advocacy is that it is driven by the people" (Hall, 2010, p.1). Hall (2010) stated that grassroots advocacy is "grounded in the belief that people matter and that their collective voices are powerful in shaping policy" (p.1).

Summary

In the review of literature--a radon definition, the health effects of radon exposure, radon statistics specific to Montana, and a brief description of public health policy development and advocacy methods were reviewed. Based on this review of the literature in terms of the data on radon and its relationship to lung cancer (specific aim one), it can be concluded that there is a direct correlation to radon exposure over time and the risk for development of lung cancer. The major finding of the review of literature is that while there are EPA recommendations for radon testing in schools, there are no federal guidelines mandating testing.

CHAPTER 3

METHODOLOGY

The purpose of this professional project was three-fold: 1) to inventory and analyze the regulatory policies addressing indoor radon exposure in public buildings, 2) to compare and contrast the policies for protecting school children from radon exposure, and 3) to recommend a best practice policy for presentation to the Montana State Attorney General and state nursing organizations. Keeping the purposes in mind, the specific aims of this project were:

1. Review what is known about the relationship between radon as a carcinogen and lung cancer.
2. Inventory the current policies for administrative, constitutional, and statutory laws for testing radon in public schools in the U.S.
3. Identify the best practice for testing radon in public schools based on current policies.

Design

This professional project served to describe the current policy environment in the United States in terms of radon testing in public schools. A policy inventory was conducted using LexisNexis Academic of each state in the U.S. for statutory, administrative, or constitutional statutes, codes, and regulations concerning radon. A search criterion was that the policy had to have at least five occurrences of the word radon to filter out policies where radon was incidental. Results were organized into categories separating policies governing radon professionals from those that directly addressed indoor air quality for vulnerable populations--in this case school children.

Procedure

Those states that had a policy in place in relation to school children were then reviewed in detail further utilizing the LexisNexis Academic database. Each of the statutes, codes, or regulations were examined in detail and a comparison chart was developed for analysis of best practices. Additionally, a data analysis plan was created by organizing each state by the presence or absence of a policy for radon testing in schools and by degree of risk based on the EPA's zone designation. These categories were then used to determine a best practices policy proposal for testing radon in Montana schools.

CHAPTER 4

RESULTS

Introduction

The results of the policy inventory utilizing LexisNexis Academic were that states ranged from zero to 53 radon policies across 10 categories. Results were sorted for those specific to children and schools which revealed nine states that had state laws mandating radon testing in public schools. No federal mandates or local policies that required radon testing in schools were found. See Appendix A and Figure 4 for a concise summary of the findings detailed below. The analysis demonstrated that 36 states had greater than 50% of counties in zones one and two (moderate to high risk for radon exposure) but only eight of those states had health policies for testing radon in schools.

Details of Inventory Findings

Colorado

Colorado (6 CCR 10-102 1991) mandates that each school should have completed radon tests per EPA guidelines by March 1, 1991. Mitigation and retesting are per EPA guidelines as stated in the EPA's Radon Measurements in Schools, Revised Edition (1993). Any schools constructed after 1991 should have the radon tests completed within 19 months of the date of occupancy. Colorado schools that were remodeled after 1991 shall notify the state department of the remodeling so that the department can assess for the need for any additional radon testing. The results of the radon testing should be on file at each school and available for review.

Connecticut

Connecticut has a General Statute 10-220d Duties of boards of education (2004) that requires radon testing prior to January 1, 2008 and every five years thereafter for every school building that is or has been constructed, extended, renovated, or replaced after January 1, 2003. The statute asks that the local or regional board of education determines their own inspection and evaluation program of indoor air quality and gives the EPA’s Indoor Air Quality Tools for Schools Program (EPA, 2010) as an example. The Connecticut rules not only mandate the testing of radon levels but also other indoor air quality potential hazards. The statute mandates that the boards of education make the results available for the public to review at a board of education meeting or on the school’s web site. Connecticut also mandates regulating the testing of radon in child day care centers or group day care homes unless the facility is subject to the regulations of General Statute 10-220 Duties of boards of education (2004). Connecticut State agency policy 19a-79-7a Child day care centers and group day care homes (2008) states that if the center uses the basement level or first floor of the building, a minimum of one radon test should be conducted by a services listed by the National Radon Proficiency Program and approved by the department. The test should be completed during the months of November to April and the results posted with the license. The Department of Public Health should be notified of results. If the samples of radon gas in the air are equal or greater than 4.0 pCi/L, mitigation should follow by a qualified residential mitigation service provider.

Florida

Per Florida Statute 64E-5.1208 Measurement requirements and procedures (1996) rules, the Department of Health mandates radon testing of all public and private school buildings, all state owned, state operated, state regulated, or state licensed 24-hour care facilities, and all state licensed day care centers for minors which are located in counties designed within the Department of Business and Professional Regulation's Florida Radon Protection Map Categories as "intermediate" or "elevated radon potential". The statute dictates that all initial measurements be conducted in twenty percent of the habitable first floor spaces and reported within one year of license approval. A second follow up test must be completed in five percent of habitable first floor space within five years of occupancy and all results reported by the sixth year of occupancy. No further testing is necessary unless significant structural changes occur. The Mandatory Radon Measurement Protocols provided by the Florida Department of Health (2010), is utilized to guide testing, mitigation, and retesting.

Iowa

Iowa requires by State Statute 109.11 Child care centers (2013) that facilities provide sufficient ventilation to maintain adequate indoor air quality. Adequate indoor air quality is assessed by radon testing performed as prescribed by the Iowa Department of Public Health (2014) at 641--Chapter 43. The testing should be completed within one year of being issued an initial or renewal license for centers that operate in facilities that are at ground level, use a basement area as program space, or have a basement beneath the program area. The statute states that testing shall be required if test kits are available from the local health department or the Iowa Radon Coalition. If the test demonstrates elevated radon levels above 4pCi/L, a plan using radon mitigation procedures established by the state department of public health shall be developed with and approved prior to a full license being issued.

Illinois

The Illinois Statute 105 ILCS 5/10-20.48 Radon testing (2010) recommends that every occupied school building be tested every five years for radon based on the rules established by the Illinois Emergency Management Agency (IEMA). Any new schools should be built using radon resistant new construction techniques as described by the EPA document, Radon Prevention in the Design and Construction of Schools and Other Large Building (EPA, 1994). Illinois states that each school district may maintain, make available for review, and notify parents and faculty of test results. The school district shall also report radon results to the State Board of Education, which shall then prepare a report every two years from all the schools to be submitted to the General Assembly and the Governor. The IEMA regulates who can be exempt from being required to be a license radon professional for the testing, but dictates that the school district can have specified employees attend an IEMA approved Internet based training course on school radon testing. Any test kit can be used as long as it is provided by a laboratory licensed in accordance with the Radon Industry Licensing Act. If results of the radon testing are at or above 4 pCi/L the school district should hire a licensed radon professional to repeat the measurements before any mitigation decisions are made. If the levels are still 4 pCi/L or above after retest, mitigation should be performed by a licensed radon mitigation professional as designated by IEMA.

Illinois also regulates the radon testing of licensed day care centers, license day care homes, and licensed group day care homes by 225 ILCS 10/5.8. This statute states that these buildings must test once every three years after January 1, 2013 per rules established by the Illinois Emergency Management Agency and that effective January 1, 2014 testing will be required as part of the initial licensing and renewal licensing. The report of the most recent testing shall be posted in the facility next to the license and copies provided to parents upon request. The facility must also include with the report the following statement:

> "Every parent or guardian is notified that this facility has performed radon measurements to ensure the health and safety of the occupants. The Illinois Emergency Management Agency (IEMA) recommends that all residential homes be tested and that corrective actions be taken at levels equal to or greater than 4.0 pCi/L. Radon is a Class A human carcinogen, the leading cause of lung cancer in non-smokers, and the second leading cause of lung cancer overall" (105 ILCS 5/10-20.48, 2010).

New Jersey

New Jersey State Statute 18A:20-40 Testing for radon in public school building (2000) states that every public school building should be tested for radon at least once every five years. The Commissioner of Education, in consultation with the Department of Environmental Protection, shall determine the extent of testing and the locations for the testing. The superintendent of each school district, in consultation with the Department of Environmental Protection and the principal of each school, shall determine based on guidelines found in the New Jersey Department of Environmental Protection School Radon Testing Program (2004) to determine the buildings tested, the locations within each building, the method of testing, and the procedures concerning notification and circulation of testing results.

New Jersey also states that buildings in which child care centers are located must be tested at least once every five years and within 30 days of the completion of the testing procedures must post the results of the test and any measures taken or proposed to mitigate the presence of radon gas at a location within the building that is readily visible to persons having responsibility for any child that attends the child care center.

Rhode Island

Rhode Island State Statute CRIR 14-000-011School health programs (2009) mandates that all schools be tested for radon based on the Rules and Regulations for Radon Control (State of Rhode Island and Providence Plantations Department of Health, 2007). Measurements should be taken by a certified radon measurement consultant and with acceptable measurement devices and analyzed by certified laboratories. Short term testing should be taken during the months of October through March for a minimum of 48 hours in closed building conditions. Results of initial short term testing should be reported to the Department of Health within 30 days. Follow up measurements shall be required when short term measurements are greater than or equal to 4 pCi/L. Mitigation systems shall be installed in buildings that have radon levels of pCi/L or greater on annual average and shall only be installed by individual licensed as radon mitigation specialists. Post mitigation measurements shall be taken by a certified measurement consultant to ensure the effectiveness of the mitigation system. It is the responsibility of each local fire chief, local building inspector, the Director of the state Department of Health and the Director of the state Labor and Training Department to notify each school superintendent by August 1 of each year as to whether the school buildings conform to state and federal laws and regulations.

Rhode Island CRIR 03-000-018 Family child care home regulations for licensure (2009) implemented in 2013 that any family child care home provider is required to provide documentation that the home has been tested for radon and found safe for the renewal of license. Retesting shall be done every three years in accordance with the Rules and Regulations for Radon Control issued by the Rhode Island Department of Health.

Virginia

Virginia State Statute 22.1-138 Minimum standards for public school buildings (1993) mandates that by July 1, 1994 all school buildings in the Commonwealth should be tested for radon per procedures established by the EPA (1993) for radon measurement in schools. Each school should maintain files of the results and make these files available for review. The superintendent should report radon test results to the Department of Health.

West Virginia

West Virginia State Statute 18-9E-3 Air quality in new schools (1998) states that radon testing should be performed by the division of health on every new public school building within the first year after occupancy and at least every five years thereafter. The testing should include all major student occupied areas at or below ground level and if radon is present in amounts greater than the amount determined acceptable by the rules of the School Building Authority, any industry accepted mitigation technique shall be used to mitigate as determined by the School Building Authority.

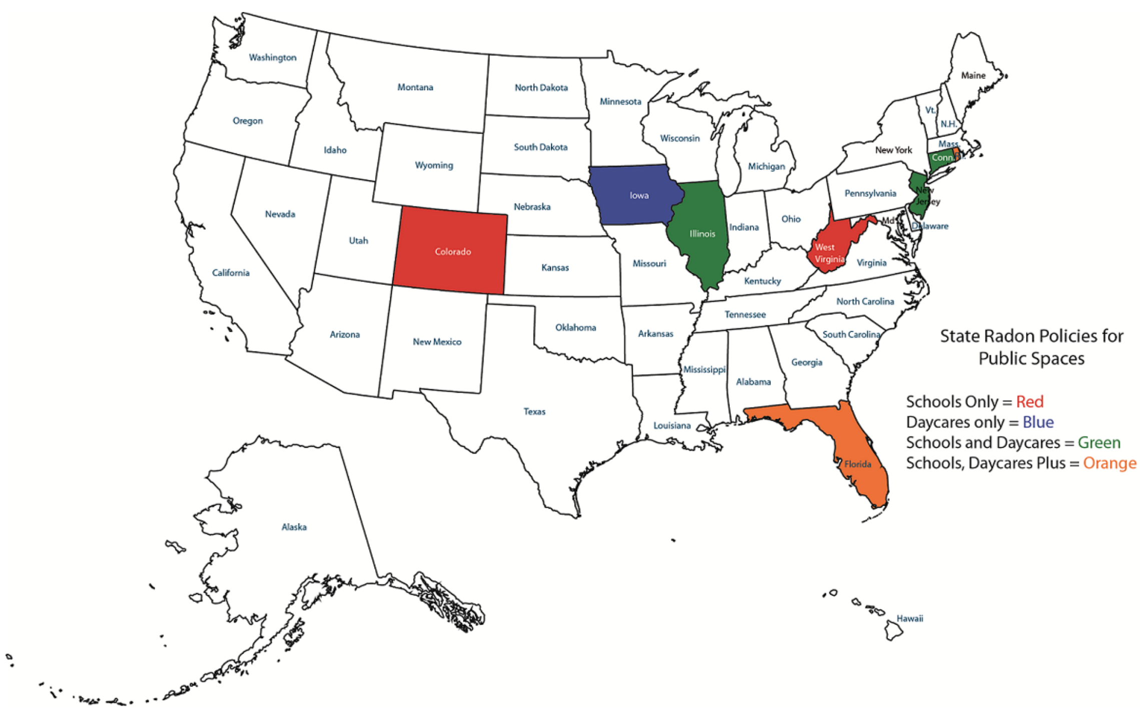

Figure 4. US State Radon Policies Map

EPA Risk Designation

To summarize, the primary purpose of this research study was to inventory and analyze the regulatory policies addressing indoor radon exposure in public buildings. Appendix B provides a list of each state and the percentage of counties within each state categorized by EPA zone designation. The appendix documents risk in terms of *more* or *less* in order to emphasize risk for radon exposure potential. The comparative analysis demonstrated that 36 states had greater than 50% of counties in zones one and two (moderate to high risk for radon exposure) but only eight (indicated by italics) of those states had health policies for testing radon in schools. The most important result is that 28 states with more than 50% of their counties designated as zone one by the EPA have no state policy in place to test the indoor air of public schools for radon.

CHAPTER 5

DISCUSSION

The art of crafting a well written policy is underscored in the findings from this project where the inventoried policies shared few elements in common. There are currently very few states with a comprehensive set of public health policies to protect school children from radon exposure. The MEME model utilized to guide this project indicated the need for action based on identified environmental exposures and subsequent health outcomes (World Health Organization, 2013). A discussion of policy gaps for the highest risk students as well as recommendations for a policy for the state of Montana are included in this chapter.

Regulatory Policies

The first two purposes of this project focused on inventorying the regulatory policies that addressed indoor radon exposure, specifically those for school children and then comparing and contrasting those policies. All of the states mandated testing initially after passage of the policy. Four of the policies stated to retest within five years and one state mandated retesting within two years, indicating that the majority of existing policies found value in retesting at frequent intervals although there was not a specific interval that was consistent to all of the policies. All of the policies mandated retesting post remodel which is indicative of a best practice.

Eight of the states had specific documents to guide radon testing in schools, in addition to the regulations found within the statute. EPA (1993; 2010) documents were cited as specific reference guides in three state policies and the other states had drafted their own document that provided concise rules and direction for testing and mitigation. It can be concluded based on review of existing policies that a separate document detailing the specifics of testing regulations would be a best practice to include in future policy making.

Eight of the nine states mandated reporting of the radon test results to an agency outside of the school itself including departments of health, boards of education, and state licensing agencies. All of the policies required keeping results of testing on file at the school and one policy required notifying parents of test results. It would be best practice for a future policy proposal to include reporting guidelines, including reporting to a state agency such as the State Board of Education or State Department of Health. Reporting to a state agency would allow for compilation of state testing results and regulation of future testing recommendations and policy adjustments based on specific state results.

A finding that would not be a best practice to implement in future policies would be New Jersey’s protocol in which the statute deems testing, retesting, and mitigation to be determined by a coordinated effort of the Commissioner of Education, Department of Environmental Protection, district superintendent, and the principal. Utilizing this practice of relying on a coordinated decision from four different groups could lead to inconsistency in testing and failure of prompt mitigation. It would not be recommended to follow New Jersey’s model for a radon policy.

An interesting finding of this project is that of the nine states that have policies, eight were designated high geographical risk by the EPA (2012) as shown in Appendix B. Florida was the exceptional case in which the EPA did not consider it a high geographical risk state but there is a state policy for testing radon in schools. A hypothesis generating statement could be made about the exceptional case of Florida that high geographical risk is not a perfect predictor of policy.

Recommendations for APRN Involvement

Based on the review of literature and results of this project policy inventory, the clinical implications for the APRN is that policy makers need to be made aware of the cumulative lifetime risks from radon as do parents and caregivers. The third purpose of this project was to prepare a policy for testing radon in Montana schools based on the best practices of existing policies. The policy proposal was written keeping in mind the advocacy methods discussed in the review of literature: utilizing state attorneys general and grassroots methods.

Rationale for targeting Montana State versus a local or federal approach is the ease of implementation and the widespread effect of the initiative. A federal policy is too large of a scale for the purposes of this study. In contrast, a local policy would not effectively achieve the goals of the study of proposing a public health policy that would protect Montana's school children and teachers from the effects of radon exposure.

History supports the success of environmental health advocates in getting indoor smoking out of public buildings (Rutkow & Teret, 2010); therefore it is hopeful that the science implicating radon as a carcinogen makes a public health policy directing radon testing in schools plausible to policy makers. Health professionals such as APRN's have the opportunity to improve environmental health and address the issue of radon exposure through strategic interactions with formal and informal community leaders (Milstead, 1999). This project identified the Montana State Attorney General as a formal community leader with a unique position at the crossroads between the state's legislative, executive, and judicial branches (Rutkow & Teret, 2010; LeGreco & Canary, 2011) that would be a key stakeholder in the adoption of policy governing radon testing in Montana schools.

Rutkow and Teret (2010) suggested that a relationship between state attorney generals and the public health community could be mutually beneficial and that by sharing their own research and summarizing relevant work of others, APRN's can "provide an evidence base that will drive state attorney generals to take action". Rutkow and Teret (2010) recommended attending the National Association of Attorneys General meetings as a method to educate states attorneys about public health issues. State attorneys generals share information about their official efforts through a public information officer who is the liaison with the media. The public information officer "promotes the state attorney general advocacy efforts" (Rutkow & Teret, 2010) which could be helpful in pursuing the adoption of a state radon policy. "Additionally, public information officers disseminate pamphlets, reports, or other materials that a state attorney general creates for the public. In doing so, they promote a dynamic relationship between the state attorney general's office and the individuals the state attorney general serves" (Rutkow & Teret, 2010) and can communicate information about radon health risks and testing recommendations to the public. Ultimately, the Montana State Attorney General could politically benefit from taking a public stance for protecting school children from a known carcinogen by advocating for a public health policy such as the one this project proposes.

The authors also recommend targeting a state audience utilizing the grassroots method. The is perhaps best accomplished by approaching specific boards that would be interested in public health policy and lobbying support at the legislative level. The Montana Association of School Nurses (MASN) and the Public Health Nurses Association of Montana are two boards that would be particularly interested in supporting this public health initiative. The purpose of the MASN is to “maintain, promote, and advance quality school health services and health education throughout the state” (Nursing Network, 2013). The Public Health Nurses Association of Montana stated purpose is to “promote united and dynamic public health nursing leadership, discover innovative solutions, and influence public health policy” (Montana Public Health Association, 2010). Spenceley et.al. (2006) regards advocacy at the policy level as an extension of the advocacy role that nurses provide for individual patients, which further implicates APRN and nurse involvement. Nurses are trained to make “decisions about the allocation of resources. It is only at the level of policy that problem definition, policy implementation, and resource allocation can be examined” (Coveney, 2008, p. 516). Spenceley et.al. (2006) supports that nurses have well developed professional organization infrastructure to support policy advocacy through dialogue and participation and challenges nurses to leverage that opportunity.

Proposal to State Attorney General

Analysis of the results indicates that 100% of Montana counties are in zones one or two, indicating a high and moderate risk potential for exposure to radon. Based on the policy inventory conducted, Montana currently does not have a law that regulates the testing of radon in Montana schools. Knowing that the risk for the development of lung cancer due to radon exposure increases over time (EPA, 1993; Field, 2001; Field et al., 2000) it reasonable to conclude that a public health policy for the testing and mitigation of radon be implemented for Montana schools.

Based on a review of the established state policies and the recommendations by the Environmental Protection Agency (1993), the recommendation is for Montana to adopt a public health policy utilizing best practices. Utilizing guidelines from The Community Toolbox (Kansas State University, 2013) and the MEME model (World Health Organization, 2013) as framework, the policy should include these components:

Who: All public schools in the state of Montana, including state licensed day cares and group homes. Testing should be completed by a professional with training on radon testing.

Where: Test all frequently used rooms on or below ground level.

When to test: Test all rooms simultaneously initially for at least 48 hours after the building has been closed for twelve hours, while the normal HVAC systems are running, in closed conditions, and during the months between October and March. If this initial test is at or above 4 pCi/L, follow up testing is necessary. If the level is significantly above action level, repeat a 48 hour test. If the radon level is at 4 pCi/L or only slightly above action level, repeat test with a 90 day testing kit for a more inclusive average. Perform complete retesting of the building every five years or with any significant structural change.

Mitigation: For schools with test results 4 pCi/L or higher after the second follow up testing, consult a mitigation professional that is endorsed by the Department of

Environmental Quality for assistance in mitigation decision making. Repeat 48 hour testing method after mitigation is complete to ensure effective intervention.

Reporting: Keep results on file at school for viewing. Additionally, send the results to the district and state superintendent for compilation in a summative report. Send letter home with child to parents with testing results and action plan. Include information in the letter about home radon testing.

Limitations

A limitation to this study is that policies may have been missed that were being written during this current legislative session. Another limitation to this study is that some schools may test for radon in the absence of a state policy, such as the Bozeman school district.

Implications for the Future

Implementation of a public health policy governing radon testing in schools has a strong potential for intervention in the community. In order to support the development of public policy for the testing and mitigation of radon in schools, it would be beneficial to understand the influence of the policy implementation on parent knowledge about radon exposure and subsequent home testing. Utilizing the practices as stated in the Illinois public policy (225 ILCS 10/5.8), Montana schools could send the results of radon testing and mitigation home to parents via the school children in the form of a letter that would include the following statement:

> "Every parent or guardian is notified that this facility has performed radon measurements to ensure the health and safety of the occupants. The Montana Department of Environmental Protection recommends that all residential homes be tested and that corrective actions be taken at levels equal to or greater than 4.0 pCi/L. Radon is a Class A human carcinogen, the leading cause of lung cancer in non-smokers, and the second leading cause of lung cancer overall".

The letter should also include where home radon testing kits could be found and where additional information about radon could be obtained. The impact of this type of communication distribution has been noted in Rhode Island's statute that the provision requiring results of school radon testing to be reported to parents was associated with an increase from 40% to 87% of mitigation in high level homes (State of Rhode Island Department of Health, 2013, "2012 Accomplishments and Milestones").

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APPENDICES

APPENDIX A

STATE MANDATED POLICIES TO PREVENT SCHOOL CHILDREN'S

EXPOSURE TO INDOOR RADON GAS

Appendix A:
State Mandated Policies to Prevent School Children's Exposure to Indoor Radon Gas.

State	Policy	Testing and Retesting	Mitigation Protocol	Reporting
Colorado	CCR 10-102	Within 19 mo.; if remodeled	Per EPA (1993)	OF
Connecticut	10-220	Every 5 yrs; if remodeled	Per EPA (2010)	Present results at board of education meeting or school's website
Florida	64E-5.1208	Within 1yr; Every 5yrs and if remodeled	Per Mandatory Radon Measurement Protocols	SHD
Iowa	109.11	Within 1yr; Every 2 yrs.	SHD	State licensing regulatory agency
Illinois	105 ILCS 5/10-20.48	Every 5 yrs	ILEMA	OF, LH, LF, SBOE
New Jersey	18A:20-40	Every 5 yrs	SD, DEP and principal shall determine testing and circulation plan	
Rhode Island	CRIR 14-000-011	SHD Oct through March for 48 hrs; retest after mitigation	SHD	SHD
Virginia	22.1-138	EPA (1993)	EPA (1993) and SBOE	OF, HD
West Virginia	18-9E-3	Within 1 yr; Every 5 yrs	Per School Building Authority	SD, HD

Mo. = month, OF = on file at school, OD = on display, SD = copy to school district, HD = copy to health department, LH = letter home, LF = letter to faculty, DEP = Department of Environmental Protection, ILEMA = Illinois Emergency Management Agency, SHD = State Health Department, SBOE = State Board of Education

APPENDIX B

EPA RISK DESIGNATION

Appendix B: EPA Risk Designation.
Note: Italics indicates policy.

State	% Zone 1	% Zone 2	% Zone 3	Law Present/Absent	Risk	Sum of Zone 1 & 2
DC	0	0	100	0	Less	0
HI	0	0	100	0	Less	0
LA	0	0	100	0	Less	0
MS	0	9.8	90.2	0	Less	9.8
OK	0	11.7	88.3	0	Less	11.7
FL	0	13.4	86.6	0	Less	13.4
TX	0	15.4	84.6	0	Less	15.4
AR	0	18.7	81.3	0	Less	18.7
SC	2.2	17.4	80.4	0	Less	19.6
AK	0	24	76	0	Less	24
DE	0	33.3	66.7	0	Less	33.3
GA	2.5	34.6	62.9	0	Less	37.1
NC	8	31	61	0	Less	39
MI	10.8	38.6	50.6	0	Less	49.4
WA	17.9	35.9	46.2	0	More	53.8
OR	0	58.3	41.7	0	More	58.3
MD	33.3	33.3	33.3	0	More	66.6
AL	19.4	49.3	31.3	0	More	68.7
VA	*45.9*	*23.7*	*30.4*	*1*	*More*	*68.7*
TN	40	33.7	26.6	0	More	73.7
NY	54.8	21	24.2	0	More	75.8
RI	*40*	*40*	*20*	*1*	*More*	*80*
NE	57	25.8	17.2	0	More	82.8
NJ	*33.3*	*52.4*	*14.3*	*1*	*More*	*85.7*
VT	0	85.7	14.3	0	More	85.7
CT	*50*	*37.5*	*12.5*	*1*	*More*	*87.5*
ID	40.9	47.7	11.4	0	More	88.6
WV	*36.4*	*52.7*	*10.9*	*1*	*More*	*89.1*
MA	21.4	71.4	7.1	0	More	92.8
KY	25	68.3	6.7	0	More	93.3
MO	84.3	9.6	6.1	0	More	93.9
NV	52.9	41.2	5.9	0	More	94.1
IL	*54.9*	*42.2*	*2.9*	*1*	*More*	*97.1*
PA	73.1	25.4	1.5	0	More	98.5
AZ	0	100	0	0	More	100
NH	10	90	0	0	More	100
UT	24.1	75.9	0	0	More	100

State	% Zone 1	% Zone 2	% Zone 3	Law Present/Absent	Risk	Sum of Zone 1 & 2
IN	62	38	0	0	More	100
SD	72.7	27.3	0	0	More	100
ND	100	0	0	0	More	100
NM	21.2	78.8	0	0	More	100
WI	38.9	61.1	0	0	More	100
OH	60.2	39.8	0	0	More	100
KS	61.9	38.1	0	0	More	100
CO	*80.6*	*19.4*	*0*	*1*	*More*	*100*
MT	87.5	12.5	0	0	More	100
WY	91.3	8.7	0	0	More	100
IA	*100*	*0*	*0*	*1*	*More*	*100*
ME	75	25	0	0	More	100
MN	78.2	21.8	0	0	More	100