An Overview of

Environmental Asthma Triggers

in Montana

Montana Asthma Advisory Group

MONTANA
Department of Public Health & Human Services

ACKNOWLEDGEMENTS

LEAD AUTHOR/EDITOR

Lead Author/Editor: **MATTHEW R. HERINGTON, JD, MPH, CHES, CPH, AE-C** Environmental Health

CONTRIBUTORS

BARBARA ALLEN Program Coordinator, Montana State University Extension

ELAINE BARBIERI, MD Allergist, Great Falls Clinic

RICHARD BUSWELL, MD Pediatric Allergist, private practice

CAROL T. CADY, MD, PHD Allergist, Western Montana Clinic

STACY CAMPBELL, MA MT Tobacco Use Prevention Program, MTDPHHS

DORA CARDILLO, BS, RRT, CPFT, AE-C St. Vincent Healthcare

KATHERINE CHURCH, RN, MSN, MPH Montana Asthma Control Program, MTDPHHS

MICHAEL DICELLO, MD Allergist, Allergy and Asthma Consultants of Montana

JESSIE FRAZIER, MPH, CPH Montana Asthma Control Program, MTDPHHS

VANISSA GRANT, RRT Blackfeet Community Hospital

DEWEY HAHLBOHM, PA-C, AE-C Montana Asthma Control Program, MTDPHHS

TODD HARWELL, MPH Chronic Disease Bureau Chief, MTDPHHS

WADE HILL, PHD, PHCNS-BC Montana State University School of Nursing

ROBERT K. JEFFREY Air Quality Specialist, MT Department of Environmental Quality

KATIE LOVELAND, MPH, MSW Montana Asthma Control Program, MTDPHHS

JEREMIAH LYSINGER, MD Pediatric Pulmonologist, Billings Clinic

DAVE MANGOLD, PA-C The Allergy and Asthma Center

JUDY MURPHY, MS Montana Department of Labor and Industry

MARK NIEBYLSKI, PHD, MBA Asthma Program Section Supervisor, MTDPHHS

CURTIS NOONAN, PHD University of Montana Center for Environmental Health Sciences

PAUL G. SMITH, DO Pediatric Pulmonologist, Community Medical Center

JENNIFER ULLMAN Program Manager, MT Tobacco Use Prevention Program, MTDPHHS

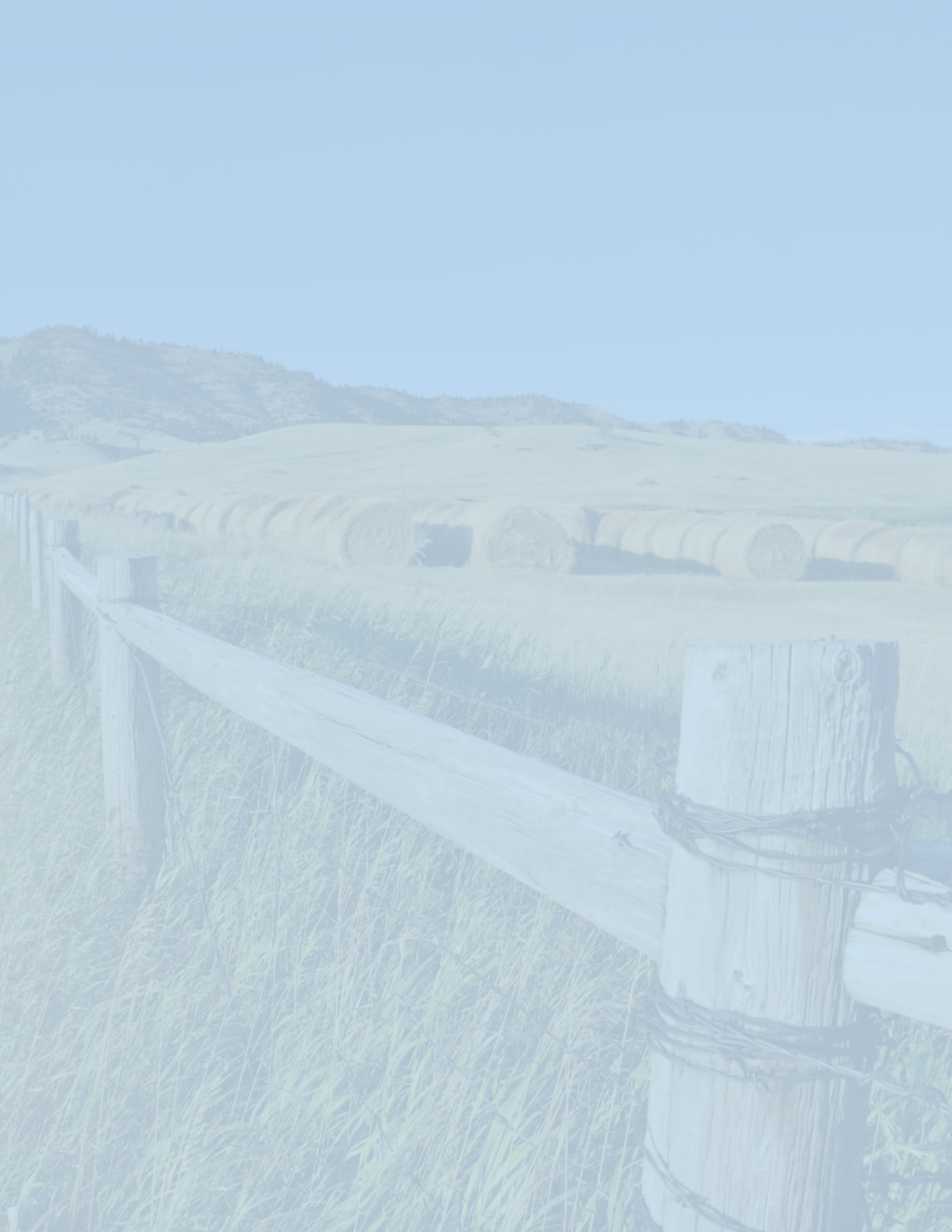
SHARON WAGNER, MPH Blackfeet Community Hospital

TONY WARD, PHD Center for Environmental Health Sciences, University of Montana

ERIC MERCHANT Section Supervisor, Air Quality Policy and Planning Section, MT Department of Environmental Quality

Note: *The reviewers listed above provided comments and suggestions during the drafting process, but do not necessarily agree with every aspect of this paper. The signatories at the end of the paper are those who fully agree with and support this statement.*

Communication regarding this paper should be directed to
KATIE LOVELAND: KLOVELAND@MT.GOV OR 406.444.7304



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MONTANA
ASTHMA CONTROL PROGRAM

Montana Asthma Control Program
PO BOX 202951
Helena, MT 59620
http://dphhs.mt.gov/asthma

MONTANA
Department of Public Health & Human Services

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Abbreviations

ACBS
Asthma Call-Back Survey

AI
American Indian

AQI
Air Quality Index

BRFSS
Behavioral Risk Factor Surveillance Survey

CDC
Centers for Disease Control and Prevention

CIAA
Clean Indoor Air Act

***DER F* 1**
Dermatophagoides farina allergen

***DER P* 1**
Dermatophagoides pteronyssinus allergen

DPHHS
Montana Department of Public Health and Human Services

EPA
US Environmental Protection Agency

EPR-3
The NHLBI's *Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma*

ETS
Environmental tobacco smoke

HEPA
High-efficiency particulate air

ICAS
Inner City Asthma Study

IOM
Institute of Medicine

µm
Micron

LIEAP
Low-Income Energy Assistance Program

MACP
Montana Asthma Control Program

MTUPP
Montana Tobacco Use Prevention Program

NAAQS
National Ambient Air Quality Standards

NHLBI
National Heart, Lung, and Blood Institute

NO_2
Nitrogen dioxide

NTHHSC
National Tribal Health Homes Support Center

O_3
Ozone

OSHA
Occupational Safety and Health Administration

$PM_{2.5}$
Particulate matter with a diameter smaller than 2.5 microns (µm)

PM_{10}
Particulate matter with a diameter smaller than 10 microns

PNAS
Prevention Needs Assessment Survey

PPM
Parts per million

SO_2
Sulfur dioxide

VOC
Volatile organic compounds

WAP
Weatherization Assistance Program

YRBS
Youth Risk Behavior Survey

PART 1 Introduction

The Montana Asthma Control Program (MACP) was established in 2007 and receives funding from the Montana State Legislature and the Centers for Disease Control and Prevention (CDC). The MACP is located within the Montana Department of Public Health and Human Services (DPHHS) and is committed to improving the quality of life for all Montanans with asthma.

Asthma is a chronic disease that cannot be cured but can be controlled. A key strategy used to control asthma is to reduce or eliminate the asthma triggers that cause or exacerbate the symptoms of the disease. It is critical that all those who work with, live with, and are affected by asthma have a good understanding of asthma triggers and how they can be effectively reduced to achieve asthma control.

The purpose of this report is to identify the key environmental asthma triggers that are present in Montana. Herein, readers will find a description of characteristics of the state that influence environmental asthma triggers. This is followed by a description of common outdoor, indoor, and work-related asthma triggers, and a discussion of how relevant these triggers are to Montana. The final segment of the paper describes current knowledge gaps, summarizes key clinical messages, and suggests public policy implications of the report's findings. See Appendices E and F for a summary table of the findings and clinical recommendations for all of the indoor and outdoor triggers discussed in this paper.

This paper was developed with the input and support of clinicians, researchers, and other asthma experts in the state of Montana who were convened over the course of a year by the MACP. A listing of the many partners who contributed to this report can be found above.

A key strategy used to control asthma is to reduce or eliminate the asthma triggers that cause or exacerbate the symptoms of the disease.

PART 2 An Overview of Asthma

What Is Asthma and What Are Asthma Triggers?

In 2007, the National Heart, Lung, and Blood Institute (NHLBI, a division of the National Institutes of Health) published the "Expert Panel Report 3: Guidelines for the Diagnosis and Management of Asthma" (EPR-3) [1]. The EPR-3 is a set of evidence-based clinical asthma guidelines designed to assist healthcare providers and patients in making appropriate decisions about asthma care. Because of its comprehensive, evidence-based coverage of the various facets of asthma, the EPR-3 is referred to throughout this report. According to the EPR-3, asthma is "a chronic inflammatory disorder of the airways…[that] causes recurrent episodes of wheezing, breathlessness, chest tightness, and coughing…These episodes are usually associated with widespread but variable airflow obstruction that is often reversible either spontaneously or with treatment. The inflammation also causes an associated increase in the existing bronchial hyperresponsiveness to a variety of stimuli" [1].

This report focuses on the "variety of stimuli" referred to in the definition above. These stimuli, otherwise known as asthma triggers, are things that cause or exacerbate airflow obstruction in individuals with asthma. More specifically, this report focuses on *environmental* asthma triggers which, for the purposes of this report, are defined as asthma triggers which one may be exposed to specifically in the indoor or outdoor environment, or in the workplace.[1]

In general, environmental asthma triggers can be classified into two groups: allergens and irritants. *Allergens* cause a Type I hypersensitivity reaction, or allergic reaction, only in individuals who are sensitized to a particular allergen. Those who are sensitized have antibodies that are specific to that allergen, and whose immune systems will therefore initiate an immunoglobulin (antibody-driven) response upon re-exposure to that allergen. Characteristic symptoms of an allergic reaction include sneezing, runny nose, and watery eyes, but in those with asthma, symptoms will also include bronchospasm, airway narrowing, and so on. Examples of some of these allergens include substances produced by cockroaches, rodents, cats and various types of pollen and mold spores. In contrast, *irritants* can cause or exacerbate airway obstruction for anyone with asthma, and may also produce respiratory symptoms in individuals who do not have asthma. Examples of asthma irritants include tobacco smoke, volatile organic compounds (VOCs), strong odors or fumes, and sulfur dioxide (SO_2).

---

[1] *Respiratory infections are significant asthma triggers acquired via the environment. However, the topic of respiratory infections is beyond the scope of this report. Appropriate prevention and management of respiratory infections includes conscientious hand-washing, covering one's mouth when coughing and sneezing, and timely immunizations.*

The Burden of Asthma

The prevalence of asthma has increased in many countries over the past several decades. Although the increase has been especially well-documented in developed countries, it appears as if the increase has occurred in developing countries as well [2]. Strikingly, in the US the prevalence of asthma increased by more than 180 percent between 1980 and 1995 [3].

As of 2010, 9.1 percent of adults in the US were estimated to currently have asthma. Similarly, in Montana, about 9.1 percent of adults were estimated to currently have asthma in 2010 [4]. Among high school youth in the US, 10.8 percent were estimated to have current asthma in 2009. In Montana, 10.4 percent of high school youth were estimated to have current asthma in 2009 [5]. Thus, the prevalence of asthma in Montana is similar to that in the US as a whole.

Asthma exacts large financial, health, and quality of life costs in the US. In 2007, asthma accounted for approximately 1.75 million emergency department visits and 456,000 hospitalizations [6]. In 2008, students suffered an estimated 14.4 million lost school days, while adults lost 14.2 million work days due to asthma [7]. The NHLBI estimates that asthma care costs in the US in 2010 equaled $20.7 billion. This figure is comprised of direct healthcare costs (approximately $15.6 billion), and indirect costs ($5.1 billion), mostly due to lost work days. The greatest component of direct care costs is medications, at approximately $5.9 billion [8]. Emergency department visits, hospitalizations, and lost school and work days due to asthma are all indicators of poor asthma control and management. Of those in Montana with asthma, nearly half of adults and more than 30 percent of children have uncontrolled asthma [9].

Although relatively rare, asthma can be fatal. In 2007, more than 3,400 people in the US died as a result of asthma [10]. In Montana, six people died from asthma in Montana in 2007, nine people died of asthma in 2008, and eight people died in 2009 [11-13].

In Montana, 9.1 percent of adults were estimated to currently have asthma in 2010. Among high school youth in Montana, 10.4 percent were estimated to have current asthma in 2009. The prevalence of asthma in Montana is similar to that in the US as a whole.

PART 3 An Overview of Montana

Although the prevalence of asthma in Montana is similar to that of the US, one cannot assume that the environmental asthma triggers present in Montana are similar to those found in other locations in the country. The demographics and geography of Montana are quite different from many of the locations where studies of environmental asthma triggers have been conducted. These differences have implications for the significance of various environmental asthma triggers in the state. A number of these unique characteristics are discussed below.

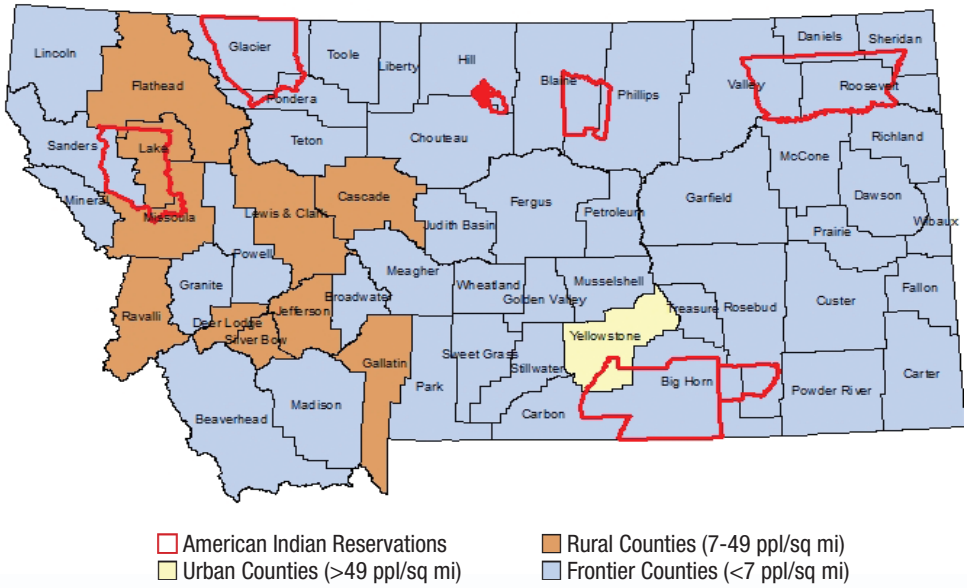
Demographics

Population

As of 2010, the United States Census Bureau estimated that 989,415 people lived in Montana, making Montana the seventh least-populated state [14]. In general, the central and eastern portions of the state are sparsely populated. However, the largest city in Montana—Billings—is located in the south central part of the state. Billings has an estimated population of slightly more than 100,000 people [15]. Put another way, Billings is less than five percent of the entire population of Chicago, Illinois. At least nine US cities have a larger population than the entire state of Montana.

Although small in population, Montana is the fourth largest state by area. Montana's large area combined with its small population results in a very low population density (6.8 persons per square mile) [16]. Only two states-Wyoming and Alaska-have a lower population density than Montana [14].

Figure 1. Population density, by county, Montana



When examining the population density of individual counties in Montana, it becomes clear that the vast majority are sparsely populated. Only one county—Yellowstone County (which contains the city of Billings)—has a population density greater than 49 persons per square mile. All other counties can be classified as "rural" or "frontier" counties. A map of population density by county in Montana is presented on the previous page [17]. The low population density has implications for the types of environmental asthma triggers present in the state. In particular, the high volumes of motor vehicle traffic that are present in urban areas around the US, and the photochemical smog often associated with them, are virtually absent in Montana.

Race and ethnicity

The US population is quite diverse with regard to race and ethnicity. Currently, the population of the US is 64 percent non-Hispanic white, 16 percent Hispanic, 13 percent non-Hispanic black, and five percent non-Hispanic Asian. Less than one percent of the US population identifies themselves as non-Hispanic American Indian [14, 18] .

In contrast, the population of Montana is approximately 90 percent non-Hispanic white, six percent non-Hispanic American Indian, three percent Hispanic/Latino, and less than one percent non-Hispanic black or non-Hispanic Asian (see Table 1) [14].

Table 1. Racial/Ethnic composition of the US vs. Montana [14, 18]

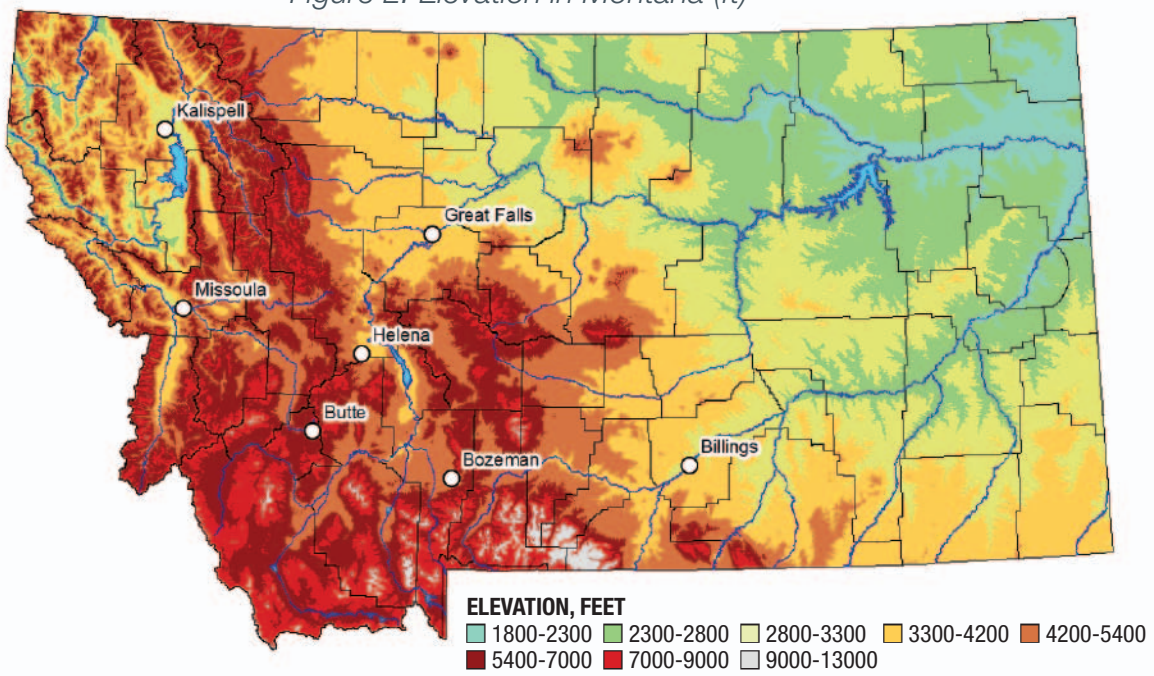
RACE/ETHNICITY	UNITED STATES (%)	MONTANA (%)
Hispanic/Latino	16	3
Non-Hispanic Asian	5	<1
Non-Hispanic Black	13	<1
Non-Hispanic White	64	90
Non-Hispanic American Indian	<1	6

Current asthma prevalence in the US is higher among the American Indian population than among some other groups [10], but surveillance within Montana suggests a wide range of asthma prevalence between tribal communities [19]. Available data in Montana suggest that the higher prevalence of asthma among American Indians in Montana is not independently associated with race, but is linked to the disproportionate exposure to risk factors for asthma (e.g. obesity, low household income, smoking) [20]. This evidence reveals the need for programs that address both asthma disparities in American Indian populations as well as the asthma triggers to which this population is disproportionately exposed.

Geography

The geography of Montana varies a great deal across the state. The western portion of the state is mountainous with a large amount of forested land. Many of the largest cities in Montana are located in this portion of the state, including Helena, Butte, Missoula, Bozeman, and Kalispell. In contrast, the central and eastern portions of Montana are largely covered by flat plains.

Figure 2. Elevation in Montana (ft)

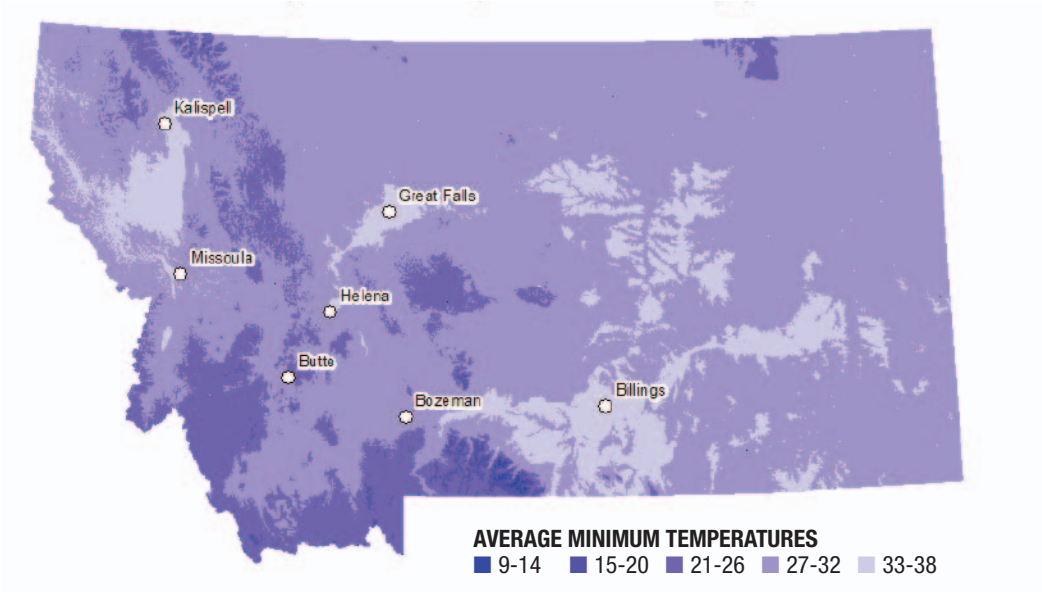


The elevation in Montana varies from 1,800 feet above sea level (in the Kootenai River area) to 12,807 feet (at Granite Peak). Half the state of Montana lies at 4,000 feet or more above sea level [21]. The six largest cities in Montana (Billings, Bozeman, Butte, Great Falls, Helena, and Missoula) all have an elevation in excess of 3,000 feet. Of these cities, Bozeman has an elevation of 4,820 feet and Butte an elevation of 5,538 feet [22].

Montana's cities are generally higher than the elevations of cities where large studies of asthma triggers have been conducted. For example, the extensive Inner-City Asthma Study (ICAS), which focused on environmental interventions designed to combat asthma triggers for children and families in inner-cities in the US, included seven highly populated cities [23]. The city with the highest elevation in the ICAS, however, was Tucson, with an elevation of less than 2,400 feet. Consequently, it is difficult to extrapolate data from such studies to Montana. As will be discussed below, geography—especially elevation—is important to consider when determining which asthma triggers may be present in a given location.

Climate

Figure 3. Average minimum temperature in Montana (˚F)



Montana is also a state of varied climates, with cold winters and hot summers. Of particular note, the lowest temperature ever recorded in the contiguous United States was in Montana. In 1954 at Rogers Pass, in the northwest region of the state, the temperature reached -70°F. At the other extreme, temperatures of as high as 117°F have been recorded in Montana [21]. Average minimum and maximum temperatures throughout the state of Montana are indicated in the two maps on this page [22].

On average, Montana receives just over 15 inches of precipitation per year [24], much of it in the form of snowfall. In comparison, Nevada averages less than 10 inches of precipitation a year [25], the Gulf Coast around 50 inches [24], and Hawaii as much as 64 inches [25]. Average annual precipitation throughout the state of Montana is indicated on the map on the next page [22].

Figure 4. Average maximum temperature in Montana (˚F)

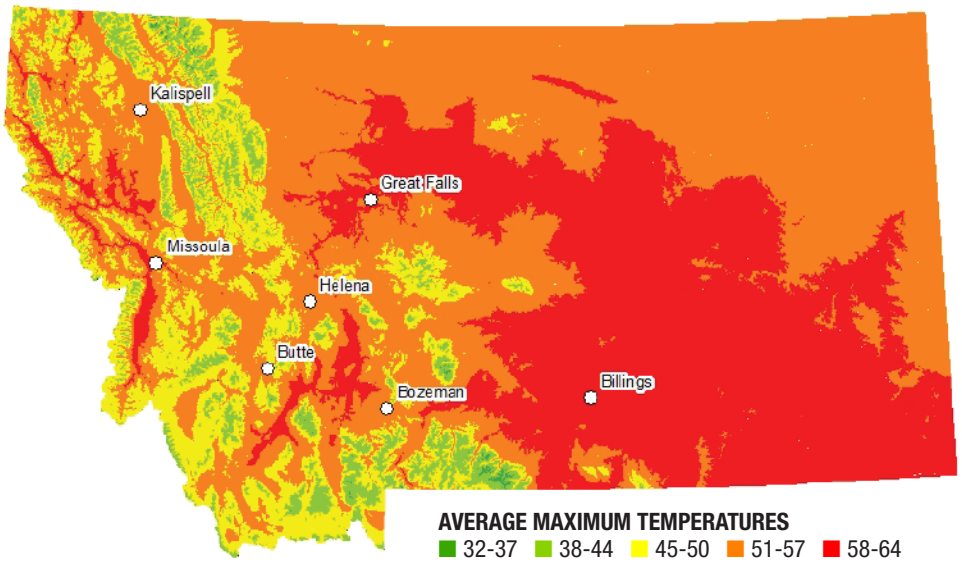
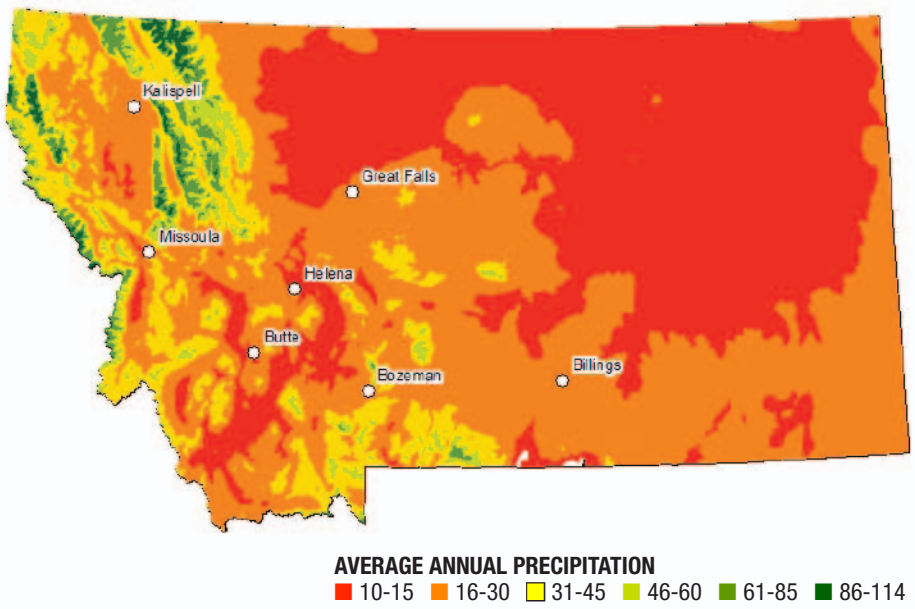


Figure 5. Average annual precipitation in Montana (Inches)



Montana's climate is also less humid than many other parts of the US, at least during the summer months. In Montana, the relative humidity in the morning hours is generally about 75 percent throughout the year. In the summer season, 35 percent relative humidity is normal during the afternoon hours. However, relative humidity in the afternoon remains high in the wintertime, averaging about 70 percent [26]. In general, humidity tends to be higher in the western portion of the state [21]. See below for a comparison of humidity levels in other US cities (Table 2) [27]. The low levels of precipitation and low relative humidity have implications for the presence of environmental asthma triggers, as dampness is associated with asthma exacerbations and will be discussed below.

Table 2. Afternoon relative humidity levels in selected US cities.

CITY	AVERAGE % HUMIDITY (JUNE, JULY, AUGUST)	AVERAGE % HUMIDITY (DECEMBER, JANUARY, FEBRUARY)
Las Vegas, NV	14	31
Billings, MT	34	55
Missoula, MT	34	74
Seattle, WA	51	73

With these important characteristics in mind, we now discuss the available data for indoor and outdoor environmental asthma triggers within Montana.

PART 4 Indoor Triggers

Tobacco Smoke

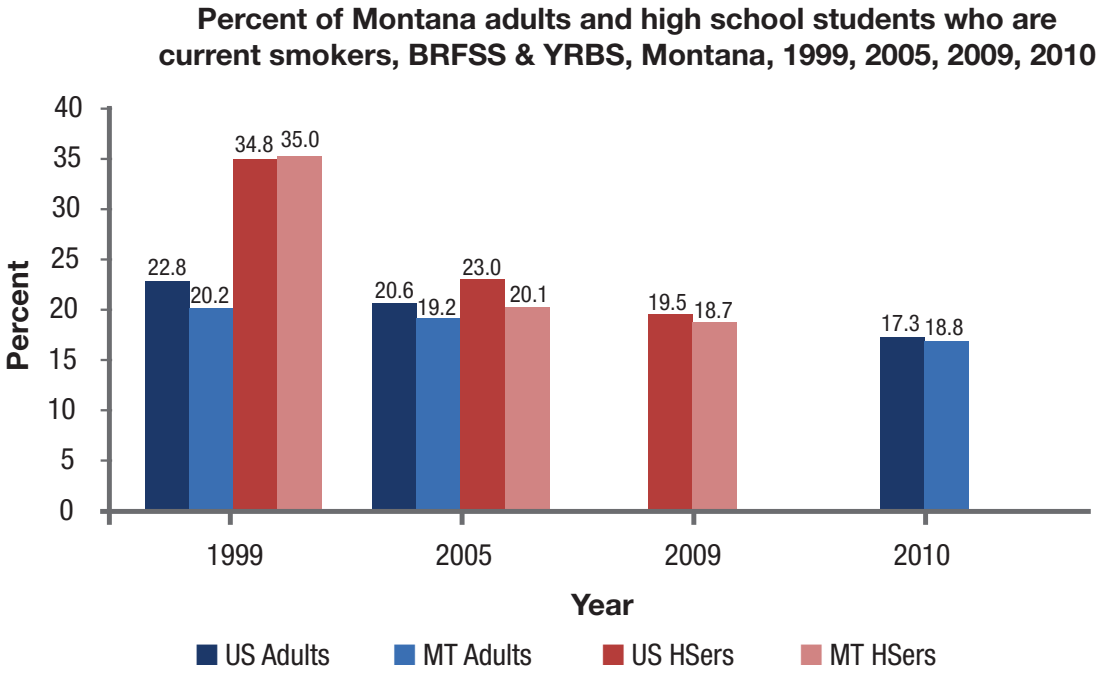
There is strong evidence to demonstrate that environmental tobacco smoke (ETS), also known as secondhand smoke, is an asthma trigger. Tobacco smoke irritates the airways, contributing to asthma attacks. Tobacco smoke has also been linked to a wide variety of other illnesses including chronic obstructive pulmonary disease, heart disease, and various cancers.

"Clearing the Air: Asthma and Indoor Air Exposures," a report released by the Institute of Medicine (IOM) in 2000, assessed the available scientific evidence for a wide variety of potential asthma triggers present in the indoor environment [28]. See Appendix C for a summary table with the IOM classifications for all of the asthma triggers addressed in this paper. With regard to ETS, the report concluded that there was "sufficient evidence of a causal relationship" between exposure to ETS and the exacerbation of asthma in sensitive individuals of preschool age. "Limited or suggestive evidence of an association" was found to exist between ETS and the exacerbation of asthma in sensitive older children and adults. The IOM report further found that there was "sufficient evidence of an association" between exposure to ETS and the development of asthma in preschool-aged children. Thus, ETS may be characterized not only as an asthma trigger, but also as a possible contributor to asthma development in certain populations.

ETS is clearly a potent asthma trigger and has been documented as such in a variety of settings. For example, one study conducted in Libby, Montana found a doubling in risk for asthma symptoms among children living in households with reported tobacco use compared to children living in tobacco-free households [29]. Multiple studies conducted in various settings have shown similar results [28].

The prevalence of tobacco smoking has declined over time in Montana, as it has nationally (See Figure 6) [30-32]. The decreasing prevalence of tobacco smoking in Montana is similar to that of the US as a whole.

Figure 6. Comparison of adult and high school smokers in the US and in Montana



In 2005, the Montana State Legislature amended the Montana Clean Indoor Air Act (CIAA), resulting in a significant strengthening of Montana law with regard to the prevention of exposure to ETS [30]. The revised law requires all enclosed public places and workplaces to be smoke free, and requires businesses to prominently place "Smoke-Free" signs at all public entrances. However, substantial numbers of Montanans are still regularly exposed to ETS. In 2008, just over 43 percent of 8th, 10th, and 12th grade students reported having been exposed to ETS in a room in the previous 30 days [31]. Similarly, 33 percent of 8th, 10th, and 12th grade students reported having been exposed to ETS in a vehicle in the previous 30 days [31]. Although exposure to ETS in a room has decreased over time, exposure to ETS in a vehicle remained stable for 8th, 10th, and 12th graders between 2004 and 2008 [31]. No data are available on exposure to ETS specifically among young children (less than 12 years old) in Montana [32], although an estimated 13 percent of children with asthma aged zero to 17 years old currently live with a smoker [33]. In Montana, 14% of adults with asthma report that someone smoked in their home in the last 30 days [33].

In addition to exposure to ETS, Montanans with asthma are exposed to tobacco smoke due to their personal use. Survey data estimate that 24 percent of high school students in Montana with current asthma smoked tobacco products in the previous 30 days, as compared to 18.6 percent of high school students without asthma [34]. Furthermore, 23 percent of Montana adults with asthma were current smokers in 2008 and 2009, as compared to 17 percent of adults without asthma [34]. Thus, one should not assume that those with asthma are nonsmokers.

The EPR-3 guidelines recommend that healthcare providers ask patients about their smoking status; the guidelines additionally recommend that healthcare providers consider referring adults who smoke and have young children with asthma to smoking cessation programs. In general, the EPR-3 advises those with asthma to not smoke and to avoid exposure to ETS [1].

CLINICAL RECOMMENDATIONS FOR PATIENTS WHO SMOKE OR WHO MAY BE EXPOSED TO ETS:

- *Ask patients with asthma about their smoking status*
- *Recommend smoking cessation resources, such as 1-800-QUIT-NOW*
- *Provide targeted education to adolescents regarding smoking risks*
- *Provide targeted education to adults who smoke and live in homes with children, particularly children with asthma*
- *Advise patients with asthma to avoid tobacco smoke and to not allow anyone to smoke in their home or vehicle*

Particulate Matter

The term "particulate matter" refers to various particles, both liquid and solid, that are suspended in the air. Some sources of particulate matter include pollen, bacteria, emissions from certain factories, motor vehicles, tobacco smoke, furry and feathered animals, fireplaces, and wood stoves [35]. Particulate matter is present in both the outdoor and indoor environments. Although particulate matter is regulated in the outdoor environment by the Environmental Protection Agency (EPA), no regulatory standards exist for indoor air [35].

Particulate matter varies in size from 0.5 mm to 10^{-7} mm [36]. Oftentimes, particulate matter is classified by size as either $PM_{2.5}$ or PM_{10}. $PM_{2.5}$ refers to particles with a diameter of 2.5 microns or less, while PM_{10} refers to particles with a diameter of 10 microns or less. The different sizes of the particles have implications for their potential effects on human health. In particular, $PM_{2.5}$ particles are small enough to actually reach the alveoli (deep in the lung), whereas PM_{10} particles deposit in the proximal airways [35].

Although particulate matter is often thought to be a problem of the outdoor environment, particulate matter concentrations can, in some instances, be higher indoors. Additionally, the sources of particulate matter differ when comparing indoor and outdoor environments, with indoor sources being potentially more harmful in some settings [35].

Wood stoves and fireplaces can be sources of particulate matter, as both have the potential to emit significant emissions in the home due to the combustion of fuel. Wood stoves and fireplaces are especially pertinent to Montana, as an estimated 28 percent of adults with asthma in the state use wood stoves or fireplaces to heat their home [33]. Notably, newer, EPA-certified wood stoves can cut down on emissions significantly. Whereas some wood stoves emit between 15 and 30 grams of smoke per hour, today's EPA-certified wood stoves emit only two to seven grams of smoke per hour [37].

A wood stove changeout program in Libby, Montana demonstrated the effects of EPA-certified wood stoves. Sixteen older wood stoves were replaced with newer, EPA-certified wood stoves, and indoor $PM_{2.5}$ levels pre- and post-changeout were measured. In the participating homes, the average $PM_{2.5}$ levels dropped from 51.2 micrograms per cubic meter ($\mu g/m^3$) to 15 $\mu g/m^3$, a 71 percent decrease in average indoor $PM_{2.5}$ levels [38]. Although data on health effects were not collected in this particular study, the outcomes support the consideration of similar wood stove changeout programs when planning asthma-friendly home interventions.

Of note, the EPR-3 guidelines do not specifically address particulate matter present in the indoor environment.

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO INDOOR PARTICULATE MATTER:

- *Emphasize that particulate matter concentrations can often be higher indoors than outdoors*
- *Educate patients, especially those who rely upon a combustible appliance as their primary heat source, about EPA-certified wood stoves; direct them to www.epa.gov/burnwise for more information*

Mold (Fungi)

Humans are routinely exposed to around 200 different species of mold [28]. However, the relationship between most of these species and asthma has not been well-studied [35]. Mold genera that are often found in the indoor environment include *Alternaria*, *Cladosporium*, and *Penicillium* [39]. Mold can act as either an allergen or as an irritant to those people with asthma; approximately six to ten percent of the population is estimated to be sensitized to mold [28]. In general, mold spores are virtually always present in indoor air. In order for the mold spores to grow, however, water and moisture must be present; relative humidity higher than 50 percent favors mold growth. Thus, to reduce the risk of indoor mold growth, an indoor relative humidity of between 30 and 50 percent is considered to be ideal [40].

As mentioned above, relative humidity in Montana during the morning hours is approximately 75 percent throughout the year. Relative humidity in the afternoon averages about 70 percent during the winter, and less than 35 percent during the middle of the summer [26]. Thus, relative outdoor humidity levels would allow for mold growth in Montana. However, relative indoor humidity levels can vary based on building construction, the use of dehumidifiers, use of heating, ventilation, and air conditioning systems, and general building upkeep. Regardless of relative humidity levels, mold growth can occur in buildings with structural issues that result in problems with water such a leaky roofs or pipes. When mold is present secondary to structural issues, patients should be advised to identify and eliminate the underlying moisture condition supporting mold growth in addition to cleaning up any mold that is present [108].

In Montana, a recent survey indicated that 10.4 percent of Montana adults with asthma have seen mold in their home in the previous 30 days [33]. However, not all mold can be easily seen; mold can grow behind walls and under carpet and, hence, not be visible to the building's inhabitants. Thus, such survey results may provide only a small glimpse into the potential problem.

In addition to the presence of visible mold, dampness is sometimes used as a proxy measure for determining whether or not mold is present in a home [39]. However, it is difficult to determine the exact role of mold as an asthma trigger in a damp environment. Numerous studies have demonstrated that children who live in damp homes have increased respiratory symptoms [1]. Nevertheless, the exact contribution of mold to those symptoms is still undetermined. As dust mites are more prevalent in damp environments, it is likely that dust mite allergen may be the main etiologic agent for at least some cases of dampness-associated asthma [28].

The IOM report found that there was "inadequate or insufficient evidence to determine whether or not an association exists" between fungi or molds and the exacerbation of asthma. Nevertheless, the EPR-3 guidelines recommend considering measures that would reduce mold in the indoor environment for people with asthma. The guidelines also note that fungi tend to be a problem "in humid environments and homes that have a problem with dampness" [1]. Although the climate of Montana could not accurately be described as "humid," some indoor environments do become damp, for a variety of reasons, such as poor land grading around the home and inadequate bathroom ventilation. Anecdotal information suggests that mold can be a significant problem in some indoor environments in Montana [41]. The EPR-3 guidelines recommend the use of dehumidifiers in geographic locations where the outside humidity is high for much of the year, as well as the use of air conditioners, although both are mentioned in the context of reducing exposure to dust mite allergen.

CLINICAL RECOMMENDATIONS FOR PATIENTS WITH MOLD OR EXCESS DAMPNESS IN THEIR HOME:

- *Educate patients about signs of excess dampness*
- *Advise patients to identify and eliminate any underlying moisture conditions supporting mold growth such leaky roofs or pipes*
- *Strongly encourage the use of bathroom and kitchen exhaust fans that vent to the outdoors; those without such fans should install them or be referred to their local weatherization assistance program (the MT WAP website is www.dphhs.mt.gov/programsservices/energyassistance)*
- *Offer online resources such as: www.epa.gov/mold/pdfs/moldguide.pdf*
- *If patients wish to know the level of humidity in their home, hygrometers, or humidity sensors, can be purchased for less than $10*
- *Suggest use of a dehumidifier or fan to help to decrease ambient humidity if needed*

Furry and Feathered Pets

Theoretically, the dander, saliva or urine of all warm-blooded animals can trigger allergic reactions in humans. Thus, furry and feathered pets are potential sources of asthma triggers. Over half of all households in the United States have cats or dogs [42]. In fact, cats and dogs are so ubiquitous in the US that cat and dog allergens tend to be found in almost all homes--even those homes where no dog or cat is present [43]. Cat allergen, in particular, can be found in significant amounts in indoor environments that do not contain cats [1]. Sensitization to cat or dog allergens is very common. Thus, a substantial number of people with asthma are at risk of asthma exacerbations due to exposure to cat or dog allergen [35].

Pet ownership is common in Montana. An estimated two-thirds of Montanans with asthma have indoor feathered or furry pets [33], and an estimated 47 percent of Montana children with asthma sleep with a family pet. Over two-thirds of Montanans with asthma have carpeting in their bedroom, which tends to trap pet allergen [33].

The IOM report found that there was "sufficient evidence of a causal relationship" between exposure to cats and the exacerbation of asthma in sensitive individuals. Regarding dogs, the evidence appears somewhat weaker, with the report finding only "sufficient evidence of an association." The evidence for domestic birds as asthma triggers was found to be weaker still, with the report concluding "limited or suggestive evidence of an association" [28].

The EPR-3 guidelines recommend removal of the pet from the home if it is triggering asthma symptoms; obviously, this may be an undesirable choice for some owners. If removal is not acceptable to the owner, other steps recommended by the EPR-3 guidelines include excluding the pet from the patient's bedroom, and removing upholstered furniture and carpets from the home (or isolating the pet from these materials). The guidelines do note that high-efficiency [37] particulate air (HEPA) cleaners can reduce allergens that are airborne in the indoor environment. Vacuuming should be done by someone without asthma and when those with asthma are not present in the home. Those with asthma should wear a dust mask while vacuuming [1].

CLINICAL RECOMMENDATIONS FOR PATIENTS WITH FURRY ANIMALS IN THEIR HOME:

- *Removal of the pet from the home, if feasible*
- *Exclusion of the pet from the patient's bedroom*
- *Removal of upholstered furniture and carpets from the home*
- *Relocation of the patient from the home during vacuuming*
- *Use of HEPA-filtered vacuums and masks while vacuuming*

Nitrogen Dioxide

Nitrogen dioxide (NO_2) is a brown-colored gas with a characteristic odor. Formed during high-temperature combustion, the main source of indoor nitrogen dioxide is unvented gas appliances [44], although improperly vented furnaces and fireplaces can emit NO_2 into the indoor environment as well [28]. Although the absolute amounts of NO_2 that are released into the home from unvented gas appliances may be small, those with asthma may be especially vulnerable. Studies demonstrate that people with asthma exposed to a dose as small as one part per million have an increase in airway reactivity when measured in the laboratory setting [36]. On the other hand, the clinical significance of exposure to NO_2 is unclear; some studies have shown an effect on asthma symptoms, while others have not [44]. Nitrogen dioxide is often considered an outdoor pollutant, as ambient nitrogen dioxide levels are regulated by the EPA [45]; nevertheless, indoor levels of NO_2 can be higher than outdoor levels, as NO_2 can become concentrated in the indoor environment [28].

In Montana, approximately 25 percent of people with asthma use gas for cooking; however, survey data indicate that only four percent of adult Montanans with asthma use an unvented gas stove or fireplace.

In Montana, approximately 25 percent of people with asthma use gas for cooking [33]; however, survey data indicates that only four percent of adult Montanans with asthma use an unvented gas stove or fireplace [33].

The IOM report found "sufficient evidence of an association" between NO_2 (and other nitrogen oxides) and the exacerbation of asthma. However, the report found that this was true at "concentrations that may occur only when gas appliances are used in poorly ventilated kitchens" [28]. The EPR-3 guidelines recommend that patients with asthma avoid exposure to gas stoves and appliances that are not vented to the outside. Available evidence suggests that this is likely to be most important for people whose asthma is not well-controlled or who are on high-doses of controller medication [35].

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO NO_2 EXPOSURE AT HOME:

- *Ensure that the patient's gas appliances are vented to the outside*
- *If appliances are not vented, refer them to their local LIEAP or WAP provider; they may qualify for financial assistance through these programs*

Dust Mites

Dust mites are microscopic arachnids that feed on small pieces of organic matter, including sloughed-off human skin. Consequently, they are commonly found in such locations as carpet, upholstered furniture, bedding, and fabric [35]. In general, dust mites are more prevalent at lower altitudes and in areas of higher humidity [46]. Water is essential for the survival of dust mites; in experiments conducted at less than 50 percent relative humidity, the dust mites dried out and died [47]. Montana's mean elevation of 3,400 feet and low humidity raises the question of how common dust mites actually are in the state, but no one has conducted large-scale studies on the topic. Nevertheless, researchers have identified dust mites in other Rocky Mountain states.

Both *Dermatophagoides pteronyssinus* and *Dermatophagoides farinae,* two common species of dust mites, have been found in Colorado. One study in Denver, Colorado, found dust mites in 20 percent of bed samples [47]. As Denver has an elevation of 5,200 feet above sea level, the presence of dust mites in such an environment may be surprising. However, several of the homes in that study contained furniture that had been brought to Denver three or four months earlier from other areas of the country. Although some of the homes that did not have recently introduced furniture were found to have dust mites, the authors noted that "they contribute[d] little mite antigen and are probably of minimal clinical significance to mite-sensitive patients" [47]. With regard to other Rocky Mountain states, *D. farinae* has also been identified in New Mexico [48]. In a study conducted in Tucson, Arizona, dust mites were present in 33 percent of bed samples and 42 percent of samples taken from the floors of homes [49].

In another study, researchers examined house dust samples from bedroom carpets or mattresses of people with asthma from all around the US over a five-year period. Analysis of these samples revealed that very few dust mites were present in the house dust collected from the Rocky Mountain states. The samples collected from Montana in particular revealed no dust mites at all [48]. Consequently, the authors concluded that "except where unusual conditions of humidity occur, significant levels of house dust mites are not frequently encountered" in the Rocky Mountain region [48].

While some studies in the Rockies have sought the presence of dust mites themselves, other studies have focused on the presence of dust mite allergen (*Der* 1). A study in Colorado found that about 45 percent of samples were positive for *Der* 1, and that mean *Der* 1 levels were 1.04 micrograms of allergen per gram of dust (µg/g) [50]. Another study found mean *Der* 1 levels in Denver, Colorado to be even lower, at 0.04 µg/g [51]. When researchers looked for the presence of dust mite allergens in Los Alamos, New Mexico (at 7,200 feet above sea level), the geometric mean for *Der p* 1 was found to be 0.18 µg/g, while the geometric mean for *Der f* 1 was found to be 0.13 µg/g [52]. Still another study found that dust samples from "the intermountain steppe region" yielded mean *Der* 1 levels of 3.18 µg/g [53].

Clearly, when dust mite allergens have been detected in the Rocky Mountain region, the levels detected have been low. It has been suggested that *Der p* 1 levels of 2 µg/g are necessary for the development of sensitization in people exposed to the dust mite allergens [54]. However, there is some evidence that sensitization may occur at allergen levels even lower than 2 µg/g [55].

...the weight of the evidence suggests that dust mites are not an important cause of asthma exacerbations in Montana.

The IOM report found that there was "sufficient evidence of a causal relationship" between dust mite exposure and asthma exacerbations. Additionally, the IOM report found "sufficient evidence of a causal relationship" between dust mites and the development of asthma. This is significant, as dust mites were the only asthma triggers given that categorization in the IOM report [28]. Anecdotally, sensitization to dust mites has been reported among asthma patients in Montana [56, 57]. Nevertheless, the weight of the evidence suggests that dust mites are not an important cause of asthma exacerbations in Montana.

The EPR-3 guidelines recommend a multifaceted approach to avoiding dust mite allergens. This includes encasing mattresses and pillows in allergen-impermeable covers and washing bedsheets and blankets in hot water (> 130° F) on a weekly basis. The guidelines also emphasize that dust mite control in one's bed should have the highest priority. The guidelines additionally note that air filtering devices are not effective in removing mite allergens from the indoor environment [1].

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO DUST MITES:

- *Educate that the prevalence of dust mites in Montana is likely to be low*
- *Wash all bed linens weekly, in hot water*
- *Use allergen-impermeable covers on mattress, bedspring, and pillows*
- *Avoid use of humidifiers*

Rodents

Like other warm-blooded animals, rodents produce allergens that can exacerbate asthma in those who are sensitized to them. Rodents have been recognized as an important cause of asthma exacerbations in large cities, with mouse allergen reportedly found in almost all inner-city homes in some studies [35]. It is believed that chronic, daily exposure to rodent allergen (as might occur in one's home) can contribute to the development of sensitization to rodents [42].

A variety of rats and mice are known to live within the state of Montana. Some of these species found throughout the state include: the House Mouse, the Deer Mouse, the Northern Grasshopper Mouse, the Norway Rat, and the Bushy-tailed Woodrat [58]. The White-footed Mouse and the Western Harvest Mouse are found in eastern Montana. The Deer Mouse, in particular, is thought to be extremely prevalent in Montana.

In Montana, about seven percent of adults with asthma and ten percent of children with asthma report they have seen rats or mice in their home during the previous 30 days [33]. However, rodents are often present even when they are not visible to the home's occupants [35]. Thus, it is difficult to accurately calculate the prevalence of rats or mice within the homes of those with asthma.

The IOM report found that there was "inadequate or insufficient evidence to determine whether or not an association exists" between rodents and the exacerbation of asthma. Nevertheless, the EPR-3 guidelines note that exposure and sensitization to rodents is common among children with asthma who live in urban areas. The guidelines additionally note that exposure to mouse allergen "can be reduced by a combination of blocking access, low-toxicity pesticides, traps, and vacuuming and cleaning" [28].

CLINICAL RECOMMENDATIONS FOR PATIENTS REGARDING RODENTS:

- *Encourage patients to ensure that the home remains free of rodents by closing cracks in the walls and baseboards and by storing food properly and promptly and utilizing other Integrated Pest Management techniques*
- *Encourage patients to maintain a clean home*
- *Remind patients that, if evidence of rodents is found, low-toxicity pesticides or pesticide-free traps should be used, as pesticides could exacerbate asthma symptoms*

Cockroaches

Cockroaches are a major problem in the United States' inner cities. In the US, the two most common species are the German cockroach (*Blatella germanica)* and the American cockroach (*Periplaneta americana*). These two species are also the species to which people in the United States are most commonly sensitized [59]. The *B. germanica* in particular "is considered to be the most important domestic pest species in the developed world" [60].

Cockroaches are found in a wide variety of geographic locations and climates, with the largest number between the latitudes 30°N and 30°S in the warm and humid regions of the world [61]. Areas of US territory within these latitudes include portions of Florida, Louisiana, and Texas, as well as Hawaii, Puerto Rico, and other outlying areas. In a Florida study of 1,000 apartments, the median number of cockroaches per apartment was greater than 13,000 [60]!

Cockroach allergen is commonly found in inner-city homes within the US [1]. As with rodent allergens, cockroach allergen may be found in a home even when the cockroaches are not visible to the inhabitants [35].

Domestic cockroaches are not common in Montana [62] and very few Montanans with asthma have reported seeing a cockroach in their home [33]. In general, the significance of the cockroach as an asthma trigger in Montana is lesser than in many other parts of the US.

The IOM report determined that there was "sufficient evidence of a causal relationship" between cockroaches and the exacerbation of asthma [1]. The EPR-3 guidelines recommend that measures should be taken to control cockroaches if patients are sensitized to cockroach allergen and cockroaches are present in the home. The EPR-3 guidelines note that volatile chemical agents should not be used to kill cockroaches, as the chemicals could exacerbate asthma in susceptible individuals. Instead, cockroach traps, boric acid, and baits are recommended [1]. Because cockroaches thrive in homes with readily accessible food, water, and garbage, an important means of keeping one's home free of cockroaches is maintaining a clean home. It is important to note that cockroach allergen will be present even after the cockroaches have been eliminated, necessitating a large amount of cleaning for homes that are or have been infested [42].

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO COCKROACHES:

- *Note that there is a low prevalence of cockroaches in Montana*
- *If evidence of cockroaches is found, use low-toxicity means of killing or trapping them*
- *Maintain a clean home to decrease cockroaches*

Other Indoor Triggers

In addition to the triggers discussed above, a variety of other potential asthma triggers may be present in the indoor environment. Two additional triggers of note, but for which there is little existing evidence on their relation to Montana specifically, include ozone (O_3) and volatile organic compounds (VOCs).

Ozone is an asthma trigger that is most often associated with the outdoor environment. However, exposure can also occur in the indoor setting. In some cases, O_3 present in the indoor environment has penetrated from the outside when the outdoor levels of O_3 are high [35]. There are also potential sources of O_3 in the indoor environment. Of particular note, ionizers associated with indoor air purifiers can produce O_3, potentially triggering asthma exacerbations [28]. Copy machines may also produce O_3 [28]. The EPR-3 guidelines advise that persons with asthma avoid air purifiers that generate O_3. Based on the available evidence, there is no reason to believe that O_3 is encountered in the indoor environment in Montana any more or less frequently than in other states.

Volatile organic compounds are chemicals that exist as free vapors or that are adsorbed onto particles present in the air [28]. VOCs can originate from any number of products that are present in the indoor environment, including cleaning materials, pesticides, upholstered furniture and mattresses, and building materials [36]. Hundreds of different VOCs, including formaldehyde, have been detected in various indoor environments [28]. The EPR-3 guidelines advise clinicians to warn patients with asthma of the possibility of irritation associated with newly installed furnishings and finishes. Regarding VOCs as a group, the EPR-3 guidelines state that there is "inadequate or insufficient evidence to determine whether or not an association exists" between VOCs and the exacerbation of asthma. However, the EPR-3 guidelines do state that "limited or suggestive evidence of an association" between formaldehyde and the exacerbation of asthma does exist. The same classification is given by the EPR-3 guidelines for "fragrances" [1]. Given this information, schools and workplaces should consider adopting fragrance-free policies, including a ban on formaldehyde-containing products. As with ozone, however, there is no reason to believe that indoor levels of VOCs in Montana differ from other states.

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO INDOOR OZONE AND VOC EXPOSURE:

- *Encourage patients to disengage the ionizer feature of air purifiers*
- *Recommend that susceptible patients avoid the use of fragrances and air fresheners*
- *Recommend that susceptible patients avoid formaldehyde-containing products which include certain types of furniture and finishes*

PART 5 Outdoor Triggers

Particulate Matter

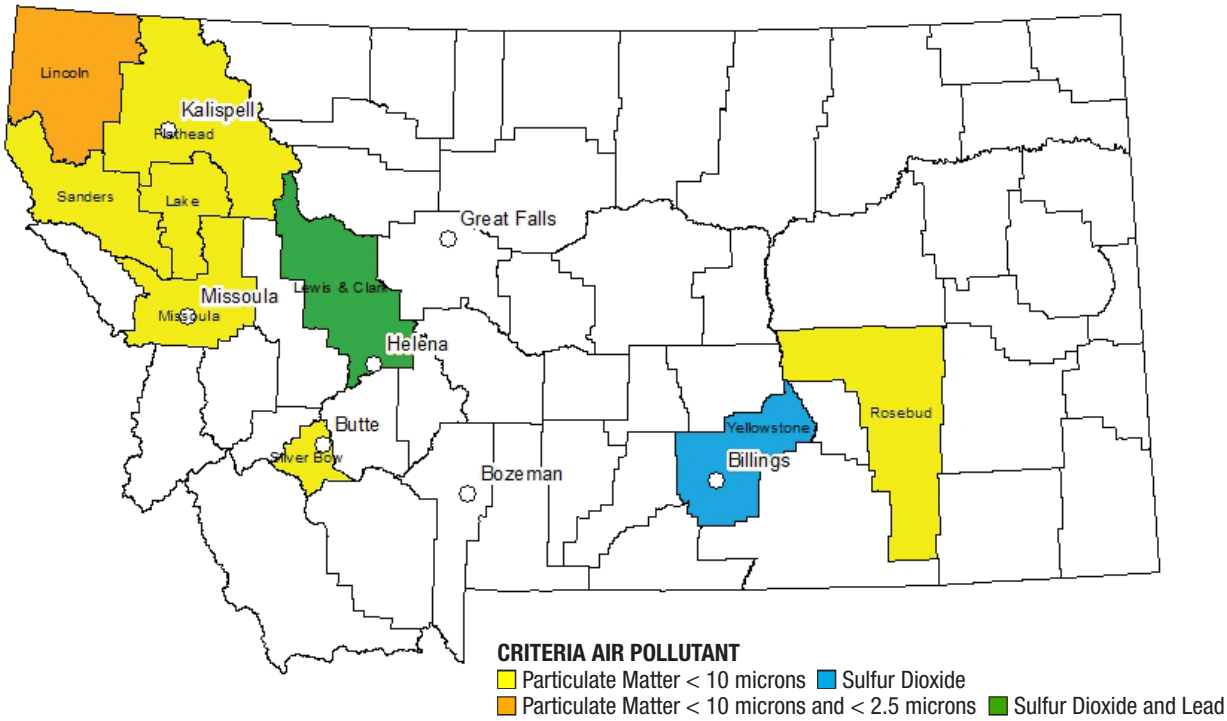
Particulate matter is an asthma trigger that is found in both indoor and outdoor environments. In the outdoor environment, particulate matter results from a variety of man-made sources. These sources include manufacturing processes, vehicle emissions, woodstove use, and mining. Natural sources include wildfires, volcanic ash, and various biological particles [36].

Among the general population, exposure to particulate matter in the outdoor environment has been linked to higher levels of morbidity and mortality [36]. Among individuals with asthma, exposure to particulate matter in the outdoor environment has been linked to asthma exacerbations and decreased lung function. When compared to $PM_{2.5}$, the coarse fraction of PM (particles between 2.5 µm and10 µm in size) is associated with an increased risk for hospitalization among people with asthma [35].

Particulate matter is one of the six criteria pollutants (along with sulfur dioxide, carbon monoxide, nitrogen oxides, ozone, and lead) regulated by the EPA's National Ambient Air Quality Standards (NAAQS) [63]. In Montana, there are several designated nonattainment areas (geographic areas that have not consistently met the clean air levels set by the NAAQS) for particulate matter. For PM_{10}, these areas include Butte, Columbia Falls, Kalispell, Whitefish and vicinity, Lame Deer, Missoula, Polson, Ronan, Libby, and Thompson Falls and vicinity. For $PM_{2.5}$, Libby is designated a nonattainment area as well [64]. A great deal of the particulate matter in Montana originates from wildfires during the summer months, as discussed in the following pages. The map on the next page illustrates the location of criteria pollutant nonattainment areas in the state (note that lead is not an asthma trigger)[65].

...exposure to particulate matter in the outdoor environment has been linked to higher levels of morbidity and mortality [40]. Among individuals with asthma, exposure to particulate matter in the outdoor environment has been linked to asthma exacerbations and decreased lung function.

Figure 7. Nonattainment areas for criteria air pollutants, Montana



In addition to wildfire smoke, smoke emitted from wood stoves also contains PM. An example of where this has been a problem is Libby, which experiences elevated levels of $PM_{2.5}$ during the winter months. In order to determine the origins of $PM_{2.5}$ in Libby, a source apportionment study was conducted in 2003 and 2004. The study found that combustion from residential wood stoves constituted greater than 80 percent of the $PM_{2.5}$ in the Libby valley [66]. The results from this study were supported by a follow-up study conducted in five cities throughout Montana, which showed that woodsmoke (likely from residential wood stoves) was the major source of $PM_{2.5}$ in each of the communities, contributing from 56 to 77 percent of the detected wintertime $PM_{2.5}$ [67]. Part of the reason for the high levels of $PM_{2.5}$ in the valley locations throughout western Montana are the atmospheric inversions that often occur in the wintertime.

Approximately 28 percent of adults with asthma in Montana report using a wood stove or fireplace [33]. However, there are no numbers available on what percentage of these are EPA-certified.

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO OUTDOOR PARTICULATE MATTER:

- *Check the Today's Air website (www.todaysair.mt.gov) to determine when to conduct outdoor activities, especially during wildfire season and atmospheric inversion conditions*
- *See recommendations in Appendix B regarding outdoor activities during periods of poor air quality*

Wildfires

Wildfire smoke is composed of a variety of different components, including: nitrogen oxides, particulate matter, and various volatile organic compounds. In particular, ambient levels of particulate matter can reach high levels during a wildfire. For example, between the summers of 2000-2010, 24-hour values as high as 175 $\mu g/m^3$ for $PM_{2.5}$ (five times the 24-hour National Ambient Air Quality Standard for $PM_{2.5}$) were recorded during Montana wildfire seasons [68, 69].

Wildfire smoke has been linked to increased hospitalizations for asthma exacerbations [70]. The effects of wildfire smoke on the human respiratory system have also been well-documented. For example, fire fighters employed in fighting wildfires exhibit decreased lung function and increased airway reactivity [71]. Some of the symptoms associated with exposure to wildfire smoke include: cough, irritated sinuses, shortness of breath, chest pain, and headaches. These effects can be seen in those with asthma. With higher levels of ambient wildfire smoke, the general population can be affected as well [72].

Montana has likely been subject to wildfires as long as humans have inhabited the region, as wildfires are a part of the natural cycle of the Rocky Mountain region. In recent years, however, the length of the average wildfire season in Montana has increased. Comparing the time period of 1970 to 1986 with that of 1987 to 2003, the average wildfire season has increased by 78 days [73]. In addition to the increased length of the wildfire season, there has been both a higher frequency of large wildfires and a longer average duration of individual wildfires in the Western US since the mid-1980s. These changes have been linked to climate changes occurring in this region of the country [73].

A recent study modeling the effects of global climate change on wildfire activity found that the Rocky Mountain forest region (encompassing most of Idaho, western Wyoming, and western Montana) is predicted to experience the largest amount of wildfire activity within the US over the next 50 years [74]. Consequently, it is likely that wildfire smoke will only increase in importance as an asthma trigger in Montana in the years ahead.

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO WILDFIRES:

- *Monitor the Today's Air website (www.todaysair.mt.gov) during wildfire season, and plan outdoor activities when the air quality is at a "Good" level (See Appendix A and B)*
- *Remain indoors with the windows closed when air quality is poor*
- *Use air conditioning with the vent to the outside closed*
- *Regularly clean the air conditioning unit's filter*

Cold Air

As mentioned previously, Montana's high elevation and latitude cause temperatures to decrease dramatically during the winter months. Cold, dry air is known to cause bronchoconstriction, or the sudden contraction of the smooth muscle in the walls of the bronchi and bronchioles, in susceptible individuals.

Cold, dry air often acts in conjunction with exercise to exacerbate asthma. For example, research has shown that an individual with asthma can breathe small amounts of cold air at rest without experiencing bronchoconstriction. However, if the same person breathes in large amounts of cold air deeply and rapidly over a four- to five-minute period, bronchoconstriction does result. Similarly, studies have found that runners with asthma have symptoms during the winter, but few to no symptoms during the summer months [42]. In general, the larger the volume and the lower the humidity and temperature of inhaled air, the stronger the effect it will have as an asthma trigger [42].

Atmospheric inversions

Cold air also contributes to atmospheric inversions, especially in the winter months in the western valleys of Montana. Atmospheric inversions occur when a layer of heavier, cooler air is trapped close to the Earth's surface by a layer of lighter, warmer air. In normal conditions, the air near the Earth's surface warms and then rises, carrying pollutants with it. During inversion conditions (usually during the winter when the ground is cold or frozen), the cool, ground-level air does not warm and is unable to rise. Consequently, an increased concentration of pollutants is held at ground level [75]. In addition to indirectly causing asthma exacerbations, high concentrations of pollutants at the ground level can have other adverse effects, seen particularly among vulnerable populations such as the elderly and children. Perhaps one of the most dramatic examples of such an event occurred in London, United Kingdom, in 1952. During a five-day period in December, an inversion led to the formation of thick smog over the city, resulting in at least 4,000 excess deaths [36].

Although it is commonly known that areas in low-lying valleys in Montana are subject to atmospheric inversions, especially during the winter months, a concrete link between these inversions and exacerbations of asthma has not yet been established; there are no published studies in Montana that demonstrate such a relationship. However, as air pollution is a known asthma trigger, it is reasonable to assume that people with asthma in the state are at a greater risk for exacerbations during inversion conditions.

CLINICAL RECOMMENDATIONS IN REGARD TO COLD AIR AND ATMOSPHERIC INVERSIONS:

- *Avoid vigorous activity in very cold temperatures*
- *Pre-treat with a short-acting bronchodilator prior to conducting activity in cold temperatures*
- *Remain inside during atmospheric inversion conditions*
- *Monitor the Today's Air website (www.todaysair.mt.gov) and plan outdoor activities when the air quality is at a "Good" level (See Appendix B)*

Pollen

Pollen grains are the male gametophytes of higher plants. In general, the diameter of pollen grains ranges in size from approximately 10 µm to 60 µm [76]. Because of their small size, pollen grains are easily carried by the wind, sometimes for long distances. Allergies to a variety of pollens are commonplace among the general population in the US [35].

Tree, grass, and weed pollen are all responsible for allergic disease in individuals who are sensitized to the pollen. Among deciduous trees, pollination occurs in the time period surrounding leaf development. In North America, this typically occurs during the springtime. Grass pollen is generally seen at high levels in both the spring and the summer. Globally, sensitivity to grass pollen is most frequently the cause of allergic disease. Weed pollen is usually the most common allergen in the autumn. One type of weed, ragweed, is considered to be one of the most common causes of asthma exacerbations in North America [76].

Data from the pollen counting station located at the University of Montana in Missoula[2] show that the most common sources of airborne pollen in western Montana are pine, juniper, alder, birch, poplar, ash, maple and grass. [77].

In a recent survey conducted among people with asthma in western Montana, more than 50 percent of the respondents reported that they experienced respiratory problems due to airborne pollen exposure in the springtime. Twenty percent also reported that they stayed indoors to avoid exposure to airborne pollen during the springtime [78]. There is no solid data available on the percentage of Montanans with asthma who have allergies, or the percentage of Montanans with allergies who have asthma [77].

Since pollen can reach the indoor environment, pollen is addressed by the IOM report; it concluded that there was "inadequate or insufficient evidence to determine whether or not an association exists" between pollen exposure in the indoor environment and the exacerbation of asthma [1]. The EPR-3 guidelines contain several recommendations for people with asthma who are sensitized to pollen. These include staying indoors with the windows closed and the air conditioning on during times of day when pollen levels are highest (typically, during the middle of the day and the afternoon). The EPR-3 guidelines also recommend decreasing pollen exposure by conducting outdoor activities early in the morning [28].

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO POLLEN EXPOSURE:

- *Educate that those sensitized to pollen will have symptoms related to increased pollen levels*
- *Monitor pollen levels via the American Academy of Allergy Asthma and Immunology's website, and plan outdoor activities when pollen levels are low*
- *Remain indoors with the windows closed when pollen levels are high*
- *Use air conditioning with the vent to the outside closed*
- *Regularly clean the air conditioning unit's filter*

[2] *Located on the web at http://pollen.aaaai.org/nab/index.cfm?p= allergenreport&stationid=177*

Sulfur Dioxide

Sulfur dioxide (SO_2) is a gas that is formed during the combustion of coal and petroleum. Sources of SO_2 in the outdoor environment include coal- and oil-fired power plants, as well as a few types of industries (e.g. petroleum refining) [44]. Particulate matter and SO_2 are often emitted together, acting synergistically to cause adverse health effects.

Short-term exposures to SO_2 have been connected with a variety of health effects, including irritation to the respiratory tract and eyes [36] and increased emergency department and hospital admissions [79]. Among people with asthma, SO_2 concentrations between 0.25 and 0.50 parts per million (ppm) have been shown to cause narrowing of the airways when individuals are exercising [36]. This effect has been shown to occur quickly; at SO_2 concentrations of 1.0 ppm, airway narrowing can occur within two minutes. The effect is even more pronounced when individuals are exposed to cold, dry air [36].

Sulfur dioxide is one of the six criteria pollutants (along with particulate matter, carbon monoxide, nitrogen oxides, ozone, and lead) regulated by the EPA's National Ambient Air Quality Standards (NAAQS) [63]. In Montana, two areas are currently listed as nonattainment areas for failure to meet the former Primary SO_2 NAAQS, which was promulgated in 1971. This includes the East Helena area, in Lewis and Clark County, as well as the Laurel area, in Yellowstone County [64]. (Refer to the map of nonattainment areas of criteria air pollutants on page 24). Elevated ambient SO_2 concentrations in the East Helena area at the time of the nonattainment designation were the direct result of a large industrial source of SO_2, which is no longer in operation. Since shut-down of the industrial source, the East Helena area has achieved compliance with the NAAQS. Therefore, although the administrative nonattainment designation has not been changed, there is no longer concern about ambient levels of SO_2 in the East Helena area [109].

In 2010, EPA revised the long-standing SO_2 NAAQS. In response to a new or revised NAAQS Montana must recommend a designation of attainment, nonattainment, or unclassifiable for all areas in the state (generally by County). Montana recommended that all 56 Montana Counties, including the East Helena and Laurel areas, be designated attainment or otherwise unclassifiable based on all available information. Ambient monitoring data alone shows that East Helena is in compliance with the revised NAAQS while the Billings/Laurel area of Yellowstone County is in violation. Final EPA designations for Montana are due no later than June of 2012 [109].

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO SULFUR DIOXIDE EXPOSURE:

- *Educate regarding susceptibility when exposed to industrial air pollution, especially during cold conditions*
- *Monitor the Today's Air website (www.todaysair.mt.gov) and plan outdoor activities when the air quality is at a "Good" level (See Appendix B)*

Nitrogen Dioxide

Nitrogen dioxide is discussed in its role as an indoor asthma trigger on page 17. In the outdoor environment, automobiles are the largest source of NO_2 emissions nationally. Other common sources include some types of industry, power plants, and forest fires [35]. Ambient NO_2 also frequently occurs with other air pollutants, making it difficult to pinpoint the specific effects of outdoor NO_2 exposure [80]. Reduction of vehicular traffic in large urban areas has been linked to a decrease in asthma symptoms, which has been thought to be at least partially due to decreases in NO_2 levels [35].

The elderly and young children are at particularly high risk of experiencing adverse effects due to ambient NO_2 exposures [35]. Children living in geographic areas with elevated levels of NO_2 experience more frequent episodes of coughing [35] and hospital admission data for asthma show increases linked to increased ambient NO_2 levels [35]. More significantly, increases in NO_2 concentrations have also been associated with increased deaths, especially in young children [36].

There are currently no areas in Montana that are designated as nonattainment for NO_2. In fact, there are no areas in the entire US currently designated as nonattainment for NO_2 [64]. In Montana, wildfires can contribute to NO_2 levels, and are discussed on page 25.

CLINICAL RECOMMENDATIONS FOR PATIENTS IN REGARD TO OUTDOOR NO_2 EXPOSURE:

- *Educate that outdoor NO_2 exposure risk is low in Montana*
- *Monitor the Today's Air website (www.todaysair.mt.gov) and plan outdoor activities when the air quality is at a "Good" level, especially during wildfire season (see Appendix B)*

Ozone

In the outdoor environment, ground-level O_3 (as opposed to stratospheric O_3, which protects the Earth from potentially harmful ultraviolet rays of the sun) is the primary component of photochemical smog [36]. Ozone forms when nitrogen oxides and volatile organic compounds undergo photochemical reactions in the presence of elevated temperatures. Major outdoor sources of nitrogen oxides and hydrocarbons (and, indirectly, O_3) include automobiles, industrial processes, and power plant emissions [35].

The Montana Department of Environmental Quality has recently determined that ozone "is not currently a pollutant of concern in Montana."

Even among people without asthma, ground-level O_3 is known to cause respiratory irritation. When humans have been exposed to levels as low as 0.08 ppm, a variety of adverse physiological effects have been observed, including decreased lung function, increased reactivity in the airways, and inflammation [80] . Outdoor O_3 exposure has also been linked to asthma exacerbations. For example, children with asthma have been observed to use their rescue medication more often during times of higher ambient O_3 [81]. The numbers of emergency department visits for asthma have been shown to be increased on days with high levels of ozone. There is also evidence suggesting that O_3 exposure may interact with allergens, resulting in a larger asthmatic response in those patients with allergic asthma [35].

Although O_3 is one of the six criteria pollutants regulated by the EPA, there are currently no nonattainment areas for O_3 in Montana [64]. The Montana Department of Environmental Quality has recently determined that ozone "is not currently a pollutant of concern in Montana" [82].

CLINICAL RECOMMENDATIONS FOR PATIENTS REGARDING OUTDOOR OZONE EXPOSURE:

- *Monitor the Today's Air website (www.todaysair.mt.gov) and plan outdoor activities when the air quality is at a "Good" level, especially during the summer*

PART 6 Work-Related Asthma Triggers

Work-related asthma has been defined as "asthma that is induced by inhalation exposures in the workplace" [80]. The EPR-3 guidelines note that an observed correlation between asthma symptoms and work, as well as symptom improvement upon absence from work for several days, suggest asthma that may be work-related [1].

Work-related asthma can be divided into two categories: 1) work-exacerbated asthma, and 2) occupational asthma. Work-exacerbated asthma refers to pre-existing asthma that is exacerbated by an exposure in the workplace environment. In contrast, occupational asthma is defined as asthma which is "due to causes and conditions attributable to a particular occupational environment and not to stimuli encountered outside the workplace" [83]. Occupational asthma patients often give a "cyclic history." That is, they report that they are free from symptoms when not at work. However, when they are at work, symptoms develop as the work day progresses [84].

It is estimated that 15 to 20 percent of asthma cases worldwide are attributable to occupational exposures [85]. Various studies conducted in the US have shown the prevalence of work-related asthma among people with asthma to range from 6 to 44 percent [86-88]. Greater than 250 biological and chemical agents have been linked to work-related asthma [89]; those known as diisocyanates are believed to be some of the most common asthma triggers in the workplace environment [90]. Other triggers found in varying workplaces include cleaning products, rodents, and assorted pharmaceutical compounds [89]. A sample of asthma triggers found in various workplace environments [42, 89, 91] is listed on the following page.

Table 3. Asthma triggers commonly found in workplace environments.

ASTHMA TRIGGER	CORRELATING OCCUPATIONS
Acrylate	Adhesive handlers
Amines	Shellac and lacquer handlers, solderers
Anhydrides	Users of plastics, epoxy resins; electrical workers
Animal-derived allergens	Animal handlers
Cleaning products	Janitors, cleaners
Diisocyanates	Spray painters; insulation installers; manufacturers of plastics, rubbers, and foam; varnishers
Drugs	Pharmaceutical workers, health professionals, health-care industry workers, plastic industry workers
Dyes	Textile workers
Enzymes	Detergent manufacturers, pharmaceutical workers, bakers
Fluxes	Electronics workers, solderers
Formaldehyde, glutaraldehyde	Hospital staff, fabric, carpet, and insulation handlers; furniture industry workers
Grain dust	Grain handlers, millers, bakers
Grain mite	Farmers, grain store workers
Gums	Carpet makers, pharmaceutical workers
Latex	Healthcare industry workers
Metals	Solderers, refiners
Persulfate	Hairdressers
Seafood	Seafood processors
Sulfites	Restaurant or grocery store workers
Wood dusts	Forest workers, carpenters, cabinetmakers

Recent analysis of data from the National Health Interview Survey showed that the social services, religious and membership organizations industries had the highest prevalence of asthma in the US [92].[3] On the other hand, recent analysis of data from the National Health and Nutrition Examination Survey found that miners, healthcare workers, and teachers had the highest prevalence of asthma [93]. It is unclear from these data, however, if workers in any of these fields developed asthma as a result of their occupation. Similarly, it is also unknown whether workers in these occupations are experiencing asthma attacks as a result of exposures in their workplace or elsewhere.

The true prevalence of work-related asthma in Montana remains a large unknown.

As of May 2009, the largest occupational categories in Montana included office and administrative support (e.g. bookkeeping, accounting, and auditing clerks), sales and related occupations (e.g. retail salespersons), and food preparation and serving-related occupations (e.g. waiters and waitresses) [94]. Examples of just some of the asthma triggers that people may be exposed to in these occupational categories include VOCs (in the office and administrative support occupations, and sales and related occupations), cereals (which can generate airborne particulate matter), and enzymes (in the food preparation and serving related occupations).

There is a dearth of data available on work-related asthma in Montana. One source, however, is the Montana Asthma Call-Back Survey [95]. A recent analysis of data collected from 2006 to 2009 revealed that approximately 44 percent report that their asthma is caused by their current job or a previous job and 35 percent report that their asthma is aggravated by their current job or a previous job [96]. About 10 percent of respondents reported quitting or changing their job because it made their asthma worse. A greater percentage of men than women reported having been told by a healthcare worker that their asthma is work-related [96]. All in all, analysis of data from the Montana Asthma Call-Back Survey from 2006-2009 indicates that more than half of those with asthma in Montana may have asthma that is related to their work [96].

[3] *For more detail on these industries, refer to OSHA's Standard Industrial Classification Manual at http://www.osha.gov/pls/imis/sic_manual.html.*

The true prevalence of work-related asthma in Montana remains a large unknown. Although workers compensation claims are made for work-related asthma, the absolute numbers are small, with just a handful of claims having been made between 2004 and 2008 in Montana [97]. Data from self-reported surveys like the Montana Asthma Call-Back Survey may not be particularly reliable since clinical confirmation of the respondent's asthma diagnosis is not performed in such a survey. Similarly, examining the current occupations of people with asthma may not be helpful in determining which occupations are problematic, as the workers may have switched to another occupation that does not exacerbate their asthma.

The EPR-3 guidelines recommend that healthcare providers ask patients with asthma and who are employed about possible occupational exposures. This is especially important for those with new-onset asthma.

CLINICAL RECOMMENDATIONS REGARDING PATIENTS WHO MAY BE EXPOSED TO ASTHMA TRIGGERS AT WORK:

- *Screen for any of the possible occupations that may be associated with work-related asthma*
- *Inquire about symptoms while at work and away from the workplace*
- *If an occupational asthma case is suspected, consult with an occupational medicine physician for targeted testing and confirmation*

PART 7 Research Needs, Clinical Messages, and Policy Implications

Research Needs

Indoor triggers

Though much is known about asthma triggers in Montana, additional research is needed. One question that remains is to what extent are dust mite allergies affecting persons with asthma in Montana. Studies examining the prevalence of both dust mites and dust mite allergens could help answer this question. Because of the significant role that dust mites play in acute asthma exacerbations in other parts of the world, further knowledge about dust mites in Montana would help refine clinical and public health messages specific to the state.

Other data gaps could be filled by examining what specific factors associated with damp environments exacerbate asthma and which of these factors apply to Montana. As discussed previously, indoor dampness is associated with mold and with dust mites, and has been linked to respiratory symptoms. Although outdoor humidity levels are not high in Montana, damp indoor environments can and do exist. By gaining a clearer picture of the Montanans with asthma who are adversely affected by damp indoor environments, targeted clinical and public health messages can be formulated.

Another question that needs to be answered is whether or not EPA-certified wood stoves decrease asthma exacerbations in the indoor environment. As explained previously, particulate matter can be present in the indoor environment due to the use of wood stoves or fireplaces. Further research is needed on the link between asthma symptoms and the use of wood stoves or fireplaces, and how these symptoms can be prevented.

One question that remains is to what extent dust mite allergies affect persons with asthma in Montana.

Outdoor triggers

Knowledge gaps also exist with regard to outdoor triggers. The impact of temperature inversions on asthma exacerbations in Montana remains a large unknown. It is known that inversions result in concentrated air pollution near ground level, and that this phenomenon causes adverse health effects. However, studies are needed on the prevalence and types of adverse health effects of inversions on persons with asthma in Montana. This line of research is especially important given that inversions are frequent and widespread in Montana, especially in the western portion of the state.

Another unknown is how many Montanans with asthma are affected by wildfires in Montana. Knowing the answer to this question, as well as the characteristics of those people most affected, will then enable effective methods of prevention to be utilized. As wildfires are expected to increase over the coming years, further investigation into this area is critical.

Work-related triggers

It is clear that not enough is known about work-related asthma in Montana, especially in regard to which groups of people are most at risk. Unfortunately, there are large gaps in knowledge with regard to work-related asthma worldwide, not just in Montana. There are, however, a number of specific questions that would help to illuminate this topic. For example, it is not currently known what specific occupations in Montana put people at particular risk for work-related asthma. Also unknown is which chemical or biological agents are most often associated with work-related asthma in Montana. Accurate data on the overall prevalence of work-related asthma in Montana are needed as well.

It is not currently known what specific occupations in Montana put people at particular risk for work-related asthma. Also unknown is which chemical or biological agents are most often associated with work-related asthma in Montana.

Clinical Messages

After reviewing the data on environmental asthma triggers in Montana, a number of important clinical messages emerge for patients with asthma in the state. With the caveat that each patient is unique, and with the recognition that each patient with asthma must be individually assessed and treated based on the clinical expertise and experience of the healthcare provider, a number of general suggestions are made below.

Indoor triggers

Addressing indoor asthma triggers is especially crucial for patients with asthma in Montana. Although there are times when outdoor air quality is poor in Montana, such as during winter inversions in the western portion of the state, Montana does not have many of the outdoor air quality issues that are present in other, more-populated parts of the country (e.g. urban areas with high levels of outdoor O_3 or SO_2). While there are actions that society as a whole can take to reduce outdoor air pollution, the steps that individuals with asthma can take to protect themselves from outdoor triggers are limited. Primarily, those with asthma can protect themselves by simply remaining indoors during periods of poor outdoor air quality. In contrast, there are several measures that Montanans with asthma can take to address indoor asthma triggers, as discussed throughout this document. As noted in the EPR-3 guidelines, a *multifaceted approach* to managing indoor allergen and irritant exposure is the best strategy for persons with asthma, as individual steps to control indoor triggers are often ineffective.

Great strides have been made in decreasing the number of tobacco smokers in Montana. Because statistics show that significant numbers of people with asthma in Montana continue to smoke [34], and significant numbers of Montanans are exposed to ETS, there is a continuing need to counsel patients with asthma about avoiding exposure to tobacco smoke. The Montana Tobacco Quit Line (1-800-QUIT-NOW) continues to be an available resource for Montanans who wish to quit smoking. The EPR-3 guidelines recommend that *all* patients with asthma be counseled about the negative effects of smoking and ETS.

Another important way of improving indoor air quality is through the use of wood stoves that emit low levels of particulate matter; clinicians can provide information to patients about the EPA-certified wood stove program. This is an especially important recommendation for those Montanans who use wood combustion as the only means of heating their homes during the winter.

Other simple interventions that can help to reduce asthma symptoms include controlling triggers in patients' sleeping areas. Some recommendations include using allergen-impermeable covers on mattresses and pillows, running HEPA filters overnight in the room, and keeping pets out of sleeping areas.

Outdoor triggers

The EPR-3 guidelines for outdoor air pollution recommend "that clinicians advise patients to avoid, to the extent possible, exertion or exercise outside when levels of air pollution are high" [1]. Although the outdoor air in Montana is relatively clean, it is essential that those with asthma be warned of poor air quality days and encouraged to take appropriate precautions. Although every city and town in Montana does not have an air monitoring site, many larger communities do. The "Today's Air" website, operated by the Montana Department of Environment Quality, provides current information on air quality in Montana, and is located on the web at www.todaysair.mt.gov. The communities that monitor air quality upload their data to the "Today's Air" website on an hourly basis. Montana's Departments of Public Health and Human Services and Environmental Quality and the Office of Public Instruction collaborated in the creation of standard recommendations for holding outdoor sporting events during wildfire season [98]; see Appendix B.

Public Policy Implications

Indoor triggers

The findings of this paper have several potential public policy implications. With regard to indoor triggers, it is clear that control of environmental tobacco smoke (ETS) remains a critical priority in Montana. Although both the strengthening of government regulation and changes in social mores have resulted in decreased ETS exposure, too many people continue to be exposed to ETS. Many people with asthma continue to smoke tobacco as well.

It is vital that services continue to be provided for people who want to quit smoking and are unable to do so without assistance. Reducing the prevalence of smoking in the population will not only reduce the burden of asthma, but of many other diseases as well. Continued efforts to reduce ETS exposure, especially for people with asthma, will require commitment by government, the business sector, and local Montana communities.

According to the 2009 Montana Adult Tobacco Use Survey, the vast majority of Montanans support the Clean Indoor Air Act [99]. In spite of the passage of the CIAA, much work remains to be done with regard to preventing ETS exposure.

Although the CIAA prohibits the use of tobacco products on all school property and at school events by all who are present (with exceptions for tobacco education and American Indian ceremonies involving tobacco), just 89 of the 421 (21 percent) school districts in the state have adopted comprehensive, tobacco-free school policies. According to the 2011 Montana Youth Risk Behavior Survey (YRBS), 17 percent of high school students reported smoking at least once in the previous 30 days, six percent reported smoking on 20 or more days, and four percent smoked on school property [100]. These data indicate that schools and communities may not be doing all that they can in order to sway the state's youth away from tobacco use and smoking.

According to the 2009 Adult Tobacco Use Survey, the 18-24 year old age group continues to have the highest smoking rate among all adults [99]. As many individuals in this age group are enrolled in institutions of higher education, targeting those institutions has the potential to decrease tobacco smoking and ETS exposure. A quarter of college students begin using tobacco or increase their use while in college. Most of those students who use tobacco want to quit before they graduate. The Montana Collegiate Tobacco Prevention Initiative seeks to reduce tobacco use among this population through the establishment of student-led task forces on campuses that provide year-round education, prevention, and cessation services. These groups also work to effect policy change on their respective campuses. Presently, 10 of Montana's college campuses (almost half of those in the state) are participating in the program.

It is also crucial that programs continue to address environmental asthma triggers present in the home. According to the American Community Survey, 30 percent of Montana housing is renter occupied and 26 percent of Montana housing stock is multi-unit housing [101-103]. The 2008 and 2009 Montana Adult Tobacco Survey found that fewer than 20 percent of respondents who live in multi-unit housing are protected by a smoke-free policy set by their landlord [99, 104]. Thirty-six percent of those respondents have children 17 years or younger living with them. In spite of the lack of smoke-free policy coverage, 85 percent of Montana multi-unit renters who do not have a smoke-free policy in their building or complex are in favor of their landlord adopting a smoke-free policy [99, 104]

To fill this need, MTUPP's Smokefree, Rent-restricted, Multi-unit Housing Project seeks to assist Housing Authorities, rent-restricted, multi-unit housing owners and managers, and local decision-making bodies in the adoption of smoke-free policies. The project's goal is to reduce secondhand tobacco smoke exposure in the home among at-risk Montanans, including children and seniors [105].

To address home-related health disparities among the American Indian and Alaskan Native population, the Montana State University Extension, along with the US Department of Housing and Urban Development, established the National Tribal Healthy Homes Support Center (NTHHSC) in 2009. The Center provides assessment, education, and technical assistance to all 565 federally-recognized tribes to address indoor health hazards.[4] Areas addressed by the NTHHSC include: mold and moisture, carbon monoxide, household chemicals, unsafe drinking water, lead, asbestos, pesticides, radon, dust and dust mites, common allergens, asthma triggers, fire and safety hazards, and septic systems. Although asthma is only one health concern that is addressed by the NTHHSC, continued support and strengthening of initiatives such as this will help to ensure that the environmental asthma triggers potentially present in the home environments of vulnerable populations are recognized and mitigated.

The previously mentioned interventions are a promising start to addressing environmental asthma triggers present in the homes of Montanans with asthma. The findings of this paper indicate that such programs have the potential to improve the lives of those with asthma in the state. Continuing support of such programs, and the creation of similar programs, will alleviate suffering due to asthma in Montana.

[4] *More about the NTHHSC can be found at http://tribalhealthyhomes.org..*

Outdoor triggers

The public policy implications regarding outdoor triggers that stem from the data presented in this paper are evident. As noted previously, the length of Montana's wildfire season, as well as the frequency of large wildfires and the duration of individual wildfires, have all increased over the last several decades. Moreover, scientists have predicted that global climate change is likely to lead to further amplification of wildfire activity in Montana. With these increases in wildfires come increases in the subsequent adverse effects. To effectively decrease the numbers of Montanans with asthma who are seriously affected by wildfire smoke, preparation will require collaboration between a variety of stakeholders, including state and federal agencies, healthcare providers, the media, and the public.

It is also necessary to ensure that Montana's outdoor air remains clean. In the US, air pollution disasters have occurred in the past in locations such as: Donora, Pennsylvania (in 1948); New York (in 1953); Los Angeles (in 1954); and New Orleans (in 1955) [36]. In each of these instances, increased levels of industrial air pollution caused large numbers of people to suffer from respiratory symptoms. Such human-caused events led to needless morbidity and mortality. Fortunately, outdoor air quality has improved significantly in the US over the last 40 or so years [36]. This improvement can largely be traced to the enactment of the Clean Air Act of 1970 by Congress, and to the creation of the EPA in that same year. The Clean Air Act, which has subsequently been amended in 1977 and 1990, instituted a significant regulatory framework for controlling harmful air pollutants. A recent report from the EPA estimated that 1.7 million asthma exacerbations were prevented in 2010 alone as a result of the 1990 Clean Air Act amendments [106]. Continued regulation of outdoor air pollution will be crucial to prevent asthma exacerbations as the population of both Montana and the US continues to expand.

Work-related asthma

Although data on work-related asthma are sparse, one public policy need in Montana is obvious: a work-related asthma surveillance system. Such a system would provide more information on the magnitude of work-related asthma, as well as help to identify which occupations are most at-risk. Data from the surveillance system could then guide appropriate primary and secondary prevention policies and activities. The SENSOR program, a federal-state cooperative program initiated by the National Institute for Occupational Safety and Health, is a surveillance system which has identified cases of work-related asthma in multiple states [107]. A similar program in Montana would likely more fully illuminate work-related asthma in Montana.

PART 8 Conclusion

Although the prevalence of asthma in Montana is similar to the prevalence nationwide, the unique characteristics of Montana influence the importance of individual environmental triggers for persons with asthma in the state. This report serves as a starting point for those seeking information on environmental asthma triggers in Montana.

This report should also inform healthcare providers as they treat patients with asthma. By having this Montana-specific information, healthcare providers can supplement the education that they are able to provide. The knowledge gaps that have been identified should create an impetus for further asthma research in Montana as well. More comprehensive data about environmental asthma triggers have the potential to improve the health of Montanans with asthma. The findings of this report may also serve as a guide to those involved in developing, implementing, and evaluating public policies in Montana.

Finally, this paper demonstrates the efforts of a variety of those who have an interest in decreasing the effects of asthma in this state. Multidisciplinary collaboration from a variety of Montanans will continue to be crucial in diminishing asthma-related morbidity and mortality in Montana.

PART 9 Environmental Asthma Triggers: Online Resources

- American Academy of Allergy, Asthma & Immunology, www.aaaai.org/
- American College of Allergy, Asthma & Immunology, www.acaai.org/
- American Lung Association- Asthma, www.lungusa.org/lung-disease/asthma/
- American College of Occupational and Environmental Medicine, www.acoem.org/
- Asthma and Allergy Foundation of America, www.aafa.org/
- Canada Mortgage and Housing Corporation, Measuring Humidity in Your Home, www.cmhc-schl.gc.ca/en/co/maho/yohoyohe/momo/momo_002.cfm
- Centers for Disease Control and Prevention- Asthma, www.cdc.gov/ASTHMA/
- Centers for Disease Control and Prevention- Healthy Home, www.cdc.gov/healthyhomes/
- Environmental Protection Agency- Asthma, www.epa.gov/asthma/
- Environmental Protection Agency-A Brief Guide to Mold, Moisture, and Your Home, www.epa.gov/mold/pdfs/moldguide.pdf
- Environmental Protection Agency- An Introduction to Indoor Air Quality, www.epa.gov/iaq/ia-intro.html
- Environmental Protection Agency-National Ambient Air Quality Standards, www.epa.gov/air/criteria.html
- Institute of Medicine- Clearing the Air: Asthma and Indoor Air Exposures, www.iom.edu/Reports/2000/Clearing-the-Air-Asthma-and-Indoor-Air-Exposures.aspx
- Institute of Medicine- Damp Indoor Spaces and Health, www.iom.edu/Reports/2004/Damp-Indoor-Spaces-and-Health.aspx
- MedlinePlus- Asthma (an interactive tutorial), http://www.nlm.nih.gov/medlineplus/tutorials/asthma/htm/index.htm
- Montana Asthma Control Program, dphhs.mt.gov/asthma/National Institutes of Health- Asthma, health.nih.gov/topic/Asthma
- National Institutes of Health- Guidelines for the Diagnosis and Management of Asthma (EPR-3), www.nhlbi.nih.gov/guidelines/asthma/asthgdln.pdf
- World Health Organization- Asthma, www.who.int/topics/asthma/en/

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The following group of researchers and health professionals affirm that they agree with the content of the Montana Asthma Control Program's Consensus Statement on the Environmental Asthma Triggers in Montana:

DORA CARDILLO, BS, RRT, CPFT, AE-C St. Vincent Healthcare

KATHERINE CHURCH, RN, MSN, MPH Montana Asthma Control Program, MTDPHHS

MICHAEL DICELLO, MD Allergist, Allergy and Asthma Consultants of Montana

JESSIE FRAZIER, MPH, CPH Montana Asthma Control Program, MTDPHHS

MATTHEW R. HERINGTON, JD, MPH, CHES, CPH, AE-C Environmental Health Consultant

KATIE LOVELAND, MPH, MSW Montana Asthma Control Program, MTDPHHS

MARK NIEBYLSKI, PHD, MBA Asthma Program Section Supervisor, MTDPHHS

PAUL G. SMITH, DO Pediatric Pulmonologist, Community Medical Center

SHARON WAGNER, MPH Blackfeet Community Hospital

TONY WARD, PHD Center for Environmental Health Sciences, University of Montana

APPENDIX A Air Quality Index Guide

The EPA has created a guide in which specific colors correspond to air quality levels, so that the public can quickly understand the quality of air in their communities at any given time. Air quality is better the closer the value is to 0, and worse the closer it is to 500. This is the same color code that the Montana Department of Environmental Quality uses on its Today's Air map. More about the Air Quality Index can be found at www.airnow.gov

Air Quality Index (AQI) Table

AQI Values	Levels of Health Concern	Health Message	Colors
0-50	Good	Air quality is considered satisfactory, and air pollution poses little or no risk	Green
51-100	Moderate	Air quality is acceptable; however, for some pollutants there may be a moderate health concern for a very small number of people who are unusually sensitive to air pollution	Yellow
101-150	Unhealthy for Sensitive Groups	Members of sensitive groups my experience health effects. The general public is not likely to be affected	Orange
151-200	Unhealthy	Everyone may begin to experience health effects; members of sensitive groups may experience more serious health effects	Red
201-300	Very Unhealthy	Health alert; everyone may experience more serious health effects	Purple
301-500	Hazardous	Health warming of emergency conditions. The entire population is more likely to be affected.	Maroon

APPENDIX B Recommendations for Outdoor Sporting Events Based on Visibility Due to Wildfire Smoke

HEALTH EFFECT CATEGORY	VISIBILITY	RECOMMENDATION
Good	13.4 miles and up	Hold outdoor sporting events as usual. Athletes with asthma should keep rescue inhalers at hand. Athletes with other smoke related sensitivities should take precautions as symptoms dictate.
Moderate/ Unhealthy for Sensitive Groups	5.1 to 13.3 miles	Hold outdoor sporting events as usual. Athletes with asthma should have rescue inhalers readily available and pretreat before exercise as directed by their healthcare provider. All athletes with respiratory illness should limit outdoor activity, monitor symptoms and reduce/cease activity if symptoms arise.
Unhealthy	2.2 to 5.0 miles	Consider postponing/delaying outdoor sporting events, especially high exertion activities like soccer and track and field. If possible, move athletic practices indoors. If event/practice is held, athletes with asthma or other respiratory illnesses are advised not to participate. All athletes should limit their outdoor activity for prolonged periods of time.
Very Unhealthy	1.3 to 2.1 miles	Consider postponing/delaying all outdoor sporting events. Move all athletic practices indoors. All athletes with asthma and other respiratory illnesses are advised to stay indoors. All others should avoid prolonged exertion outdoors.
Hazardous	1.3 miles or less	Cancel all outdoor sporting events or relocate to an indoor location. Move all athletic practices indoors.
At all times, athletes experiencing respiratory symptoms should consult their personal healthcare provider		

APPENDIX C IOM Classification of Asthma Triggers Addressed in this Paper

Sufficient Evidence of a Causal Relationship			
ETS (in preschool-aged children)	Cockroach	House dust mite	Cat

Sufficient Evidence of an Association		
Dog	Fungi or molds	NO_2 + NOx

Limited or Suggestive Evidence of an Association		
ETS (in school-aged and older children, and in adults)	Formaldehyde	Fragrances

Inadequate or insufficient Evidence to Determine Whether or Not an Association Exists		
Rodents	Pollen exposure in indoor environments	VOCs

APPENDIX D Confidence Intervals for BRFSS, YRBS, and PNAS Statistics Quoted

Survey		MT	95% CI	US	95% CI
BRFSS	Current asthma (adults) (2010)	9.1	8.0-10.3	9.1	Median percent
YRBS	Current asthma (high school) (2009)	10.4	9.7-11.1	10.8	9.9-11.7
YRBS	Current smokers (high school) (1999)	35.0	32.2-37.9	34.8	32.3-37.4
YRBS	Current smokers (high school) (2005)	20.1	17.8-22.5	23.0	20.7-25.5
YRBS	Current smokers (high school) (2009)	18.7	15.2-22.8	19.5	17.9-21.2
BRFSS	Current smokers (adults) (1999)	20.2	18.1-22.3	22.8	Median percent
BRFSS	Current smokers (adults) (2005)	19.2	17.7-20.7	20.6	Median percent
BRFSS	Current smokers (adults) (2010)	18.8	17.1-20.5	17.3	Median percent
PNAS	Exposed to ETS in a room in last 30 days (2008)	43.0	42.3-44.5		
PNAS	Exposed to ETS in a vehicle in last 30 days	33.0	32.0-34.0		
BRFSS	Children exposed to smoke at home (2006-2008)	13.0	6.3-19.6		
BRFSS	American Indian adult current smokers (2010)	48.9	41.3-56.4		
YRBS	American Indian high school current smokers (2009-2011)	41.1	34.0-48.1		
YRBS	High school students with asthma who smoked in last 30 days (2007&2009)	23.7	19.4-28.0		
YRBS	High school students without asthma who smoked in the last 30 days (2007&2009)	18.6	16.2-21.0		
BRFSS	Adults with asthma who smoked in last 30 days (2008&2009)	23.1	19.6-26.6		
BRFSS	Adults without asthma who smoked in the last 30 days (2008&2009)	17.1	16.1-18.1		
BRFSS ACBS	Adults with current asthma who saw/smelled mold in the home in last 30 days (2006-2008)	10.4	6.9-13.9		
BRFSS ACBS	Adults with current asthma who have indoor feathered or furry pets (2006-2008)	65.0	59.9-70.1		

BRFSS ACBS	Children with asthma who sleep with a pet (2006-2008)	46.7	36.7-56.7		
BRFSS ACBS	Adults with current asthma who have a carpeted bedroom (2006-2008)	73.5	68.2-78.9		
BRFSS ACBS	Children with current asthma who have a carpeted bedroom (2006-2008)	67.6	58.3-77.0		
BRFSS ACBS	Adults with current asthma who use gas for cooking (2006-2008)	22.6	18.3-26.9		
BRFSS ACBS	Adults with current asthma who use an unvented gas stove or fireplace (2006-2008)	4.0	2.2-5.9		
BRFSS ACBS	Adults with current asthma who saw rats or mice in their home in the last 30 days (2006-2008)	6.5	4.2-8.9		
BRFSS ACBS	Children with current asthma who saw rats or mice in their home in the last 30 days (2006-2008)	9.6	3.3-15.9		
BRFSS ACBS	Adults who report their asthma is caused by their current job or previous job (2006-2009)	44.2	39.3-49.1		
BRFSS ACBS	Adults who report their asthma is aggravated by their current job or a previous job (2006-2009)	35.6	30.8-40.3		

Indoor Asthma Triggers Summary

	IOM Report Classification	Present in Montana?	Associated with:	At risk groups	Key Recommendations	Resources
Environmental Tobacco Smoke	■ Sufficient evidence of a causal relationship (in pre-school aged children) ■ Limited or suggestive evidence of an association (in school-aged or older children and adults)	■ Yes	■ Tobacco use	■ Smokers and those exposed to ETS in homes and cars ■ In MT, American Indians and individuals with lower income/education smoke at higher rates than the general population	■ Avoid exposure to environmental tobacco smoke ■ Do not smoke and institute smoke-free home and automobile policies ■ Encourage schools, businesses, and workplaces to prohibit smoking within 30 feet of entrances	■ Montana Tobacco Quitline: 1-800-QUIT-NOW ■ Montana Tobacco Use Prevention Program: www.tobaccofree.mt.gov
Particulate Matter	■ Not addressed	■ Yes	■ Wood stoves	■ Those people who use a fireplace or non EPA certified woodstove at home	■ If possible, avoid the use of a fireplace to heat your home ■ If you use a wood stove, use one that is EPA-certified	■ Weatherization or energy assistance program: www.dphhs.mt.gov/programsservices/energyassistance/ ■ EPA wood stove guidance: www.epa.gov/burnwise
Mold	■ Sufficient evidence of an association	■ Yes	■ Indoor dampness	■ Those living or working where damp conditions are present ■ Those living in substandard housing (Mold may only be present under floor coverings and/or behind walls and furniture)	■ Keep indoor relative humidity between 30 and 50 percent ■ Use dehumidifiers in damp areas ■ Clean dehumidifiers according to manufacturer's instructions and use fresh water daily ■ Run a fan in the bathroom during and after showering/bathing and in the kitchen during and after cooking ■ Be aware that mold growth may occur anywhere where there is excess moisture (e.g., water collecting inside wall or next to windows) ■ Seek professional assistance to clean large areas of mold growth larger than 10 square feet ■ Check for leaks and possible sources of dampness and fix when possible	■ MSU Extension Housing Program: www.msuextensionhousing.org ■ EPA's Brief Guide to Mold, Moisture, and Your Home: www.epa.gov/mold/moldguide.html ■ Damp Indoor Spaces and Health, Institute of Medicine, The National Academies Press, 2004
Furry and Feathered Pets	■ Sufficient evidence of a causal relationship (cats and dogs) ■ Limited or suggestive evidence of an association (domestic birds)	■ Yes	■ Pets that spend time indoors, esp. in bedrooms and on carpet	■ Those sensitized to pet dander (As pet allergen can be present even when no pets are present, so a large percentage of the population may be affected)	■ Exclude pets from your bedroom and keep the bedroom door closed ■ Remove upholstered carpet and furniture ■ Consider using a High-Efficiency Particulate Air (HEPA) cleaner in the home, especially the bedroom ■ In severe cases, find another home for pets	■ Asthma and Allergy Foundation of America: www.aafa.org
Nitrogen Dioxide	■ Sufficient evidence of an association	■ Yes	■ Unvented gas stoves or fireplaces	■ Those who use an unvented gas stove or fireplace	■ Avoid exposure to gas stoves and other gas appliances that are not properly vented to the outside ■ Seek assistance from weatherization and/or energy assistance programs in order to replace improperly vented gas stoves with another primary heat source	■ Montana low-income energy assistance program: www.dphhs.mt.gov/programsservices/energyassistance
Dust Mites	■ Sufficient evidence of a causal relationship	■ Limited	■ Carpets, bed linens, stuffed animals	■ Those sensitized to dust mite allergen ■ Individuals living in humid, low elevation environments	■ Encase mattresses and pillows in allergen-impermeable covers ■ Wash bed sheets and blankets in hot water (> 130° F) on a weekly basis ■ Remove wall-to-wall carpeting ■ Have someone without asthma vacuum using a HEPA-filtered vacuum	■ EPA: www.epa.gov/asthma/dustmites.html
Rodents	■ Inadequate or insufficient evidence to determine whether or not an association exists	■ Yes	■ Unsanitary indoor environments (can affect any home)	■ Those sensitized to rodent allergen ■ Those who live or work in indoor environments with rodent infestations (Rodent infestation may be present even though rodents are not visible)	■ Eliminate rodent infestations (block access, use low-toxicity pesticides, traps, clean regularly) ■ Keep home clean and free of food debris ■ Contact your local pest management agency for assistance	■ The MSU Extension Urban IPM Program: www.msuextension.org/urbanipm
Cockroaches	■ Sufficient evidence of a causal relationship	■ Very limited	■ Warm, humid climates	■ Those sensitized to cockroach allergen ■ Those who live or work in indoor environments where a cockroach infestation is present	■ Kill the cockroaches using boric acid, traps, and bait, rather than irritating sprays ■ Keep home clean and free of food debris ■ Contact your local pest management agency for assistance	■ Cockroaches: Ecology, Behavior and Natural History, William J. Bell et al, John Hopkins University Press, 2007.
Ozone	■ Not addressed	■ Yes	■ Ionizing air purifiers, copy machines	■ Those who use indoor air purifiers that generate ozone ■ Some office environments	■ Do not use indoor air purifiers that generate ozone (or disable the ionizer mechanism) ■ Find out if your office's copy machine produces ozone, and if it does, advocate for adequate ventilation in that room	■ EPA's guide to Air Cleaners in the Home: www.epa.gov/iaq/pdfs/aircleaners.pdf
Volatile Organic Compounds	■ Inadequate or insufficient evidence to determine whether or not an association exists (volatile organic compounds as a group) ■ Limited or suggestive evidence of an association (formaldehyde and fragrances)	■ Yes	■ Strong fragrances, new furnishings and finishes, some air fresheners	■ Those who have recently installed furnishings and finishes ■ Those exposed to fragrances at home or work	■ Avoid exposure to newly installed furnishings and finishes in the indoor environment ■ Use cleaning products that are less likely to irritate the airways (e.g., vinegar, baking soda) ■ If irritating cleaning products are being used in your home, leave the home while they are being used and ensure adequate ventilation afterward ■ Avoid air fresheners and other perfume-containing products ■ Use low-VOC paints	■ AAFA's Asthma and Allergy-Friendly Certification Program: www.asthmaandallergyfriendly.com/ ■ MACP's asthma-friendly cleaning products handout: www.dphhs.mt.gov/publichealth/asthma/documents/asthmacleaning_MT.pdf

Outdoor Asthma Triggers Summary

	IOM Report Classification	Present in Montana?	Associated with:	At risk groups	Key Recommendations	Resources
Particulate Matter	■ Not addressed	■ Yes	■ Wildfires ■ Wood stoves ■ Western Montana valleys during atmospheric inversion conditions	■ Communities in designated nonattainment areas for particulate matter: Butte, Columbia Falls, Kalispell, Whitefish and vicinity, Lame Deer, Missoula, Polson, Ronan, Libby, and Thompson Falls and vicinity ■ Communities with high levels of non "EPA-certified" wood stove use	■ Avoid exertion or exercise outside when air pollution levels are high ■ Watch air quality monitoring data on Today's Air website ■ Same recommendations as with indoor particulate matter (see Appendix E)	■ Montana Department of Environmental Quality's Today's Air Website: www.todaysair.mt.gov ■ EPA Particulate Matter page: www.epa.gov/pm/ and www.epa.gov/burnwise
Wildfires	■ Not addressed	■ Yes	■ Wildfire season (generally summer months)	■ Those living in areas where wildfires occur ■ Those who exercise outside in the summer	■ Monitor the Today's Air website during wildfire season and plan activities when the air quality is at a "Good" level ■ Remain indoors with the windows closed when the air quality is poor ■ Use air conditioning with the vent to the outside closed ■ Regularly clean the air conditioning unit's filter	■ Montana Fire Conditions: www.mt.gov/fire.asp ■ www.todaysair.mt.gov
Cold air	■ Not addressed	■ Yes	■ Winter, low temperatures	■ Those exercising outside in the cold	■ Avoid vigorous activity in very cold temperatures ■ Wear a covering over mouth and nose to help warm air ■ Pre-treat with a short-acting bronchodilator prior to conducting activity in very cold temperatures	■ Exercise Induced Asthma, AAFA: www.aafa.org/display.cfm?id=8&sub=17&cont=168 ■ ALA: www.lungusa.org/about-us/our-impact/top-stories/active-exercise-asthma.html
Pollen	■ Inadequate or insufficient evidence to determine whether or not an association exists (for pollen exposure in indoor environments)	■ Yes	■ Spring, summer, and fall seasons ■ Areas with juniper, alder, birch, poplar, ash, and maple trees ■ Areas with grass and weeds	■ Those sensitized to pollen	■ Monitor pollen levels via the American Academy of Allergy Asthma and Immunology's website ■ Plan outdoor activities when pollen levels are low ■ Remain indoors with the windows closed when pollen levels are high ■ Use air conditioning with the vent to the outside closed ■ Regularly clean the air conditioning unit's filter	■ Pollen and mold report for Missoula: http://pollen.aaaai.org/nab/index.cfm?p=allergenreport&stationid=177 ■ American Academy of Asthma Allergy and Immunology: www.aaaai.org
Sulfur Dioxide	■ Not addressed	■ Limited	■ Fossil fuel combustion, especially combustion associated with industry	■ Those living in designated nonattainment areas for sulfur dioxide: East Helena and Yellowstone County	■ Avoid exertion or exercise outside when air pollution levels are high ■ Watch air quality monitoring data on Today's Air website ■ Plan outdoor activities when air quality is rated "good" ■ Close air conditioner vent to the outside ■ Clean the air conditioner according to manufacturer's instructions	■ EPA's sulfur dioxide information: www.epa.gov/air/sulfurdioxide ■ www.todaysair.mt.gov
Nitrogen Dioxide	■ Sufficient evidence of an association between NO_2 and the exacerbation of asthma	■ Yes	■ Wildfires ■ Air pollution	■ Those living in areas prone to wildfires (e.g., the western portion of Montana)	■ Avoid exertion or exercise outside when air pollution levels are high ■ Watch air quality monitoring data on Today's Air website ■ Plan outdoor activities when air quality is rated "good" ■ Close air conditioner vent to the outside ■ Clean the air conditioner according to manufacturer's instructions	■ Nitrogen Dioxide information from the EPA: www.epa.gov/air/nitrogenoxides ■ www.todaysair.mt.gov
Ozone	■ Not addressed	■ Limited	■ Air pollution	■ Those exercising outside during periods of poor air quality	■ Avoid exertion or exercise outside when air pollution levels are high ■ Watch air quality monitoring data on Today's Air website ■ Plan outdoor activities when air quality is rated "good" ■ Close air conditioner vent to the outside ■ Clean the air conditioner according to manufacturer's instructions	■ Ground level ozone information from the EPA: www.epa.gov/glo/ ■ www.todaysair.mt.gov