Idaho Climate-Economy Impacts Assessment
Human Health Report

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Key Messages

- The most widespread direct and indirect impacts of climate change on Idahoans' health are from poor air quality due to wildfire smoke and high temperatures. Many indirect impacts exist that affect wellbeing, productivity, life expectancy, and economic health.
- Other Idaho climate-related health risks include vector-borne disease, diminished water quality and quantity, harmful algal blooms, and challenges related to food safety and food insecurity, mental health, and others.
- Idahoans will not experience health-related economic impacts of climate change uniformly. Idaho's geographical diversity and differences in population density, infrastructure, income, access to health and human services, age, individual human health status, and more all will influence how human health will be affected.
- Climate change-related health impacts disproportionally affect the elderly, the young, pregnant women, individuals with chronic diseases and disabilities, and people with limited access to health care and economic resources. Outdoor workers, such as those employed in agriculture, construction, and public safety, face greater impacts of smoke and temperature extremes.
- Tribal populations face particular climate-related health vulnerabilities due to loss of natural resources, physical displacement, and First Foods and economic losses, all of which impact essential spiritual and cultural practices.
- Studies have estimated climate change impacts on health care costs to be between 1% and 3% of U.S. GDP annually.
- Nonmarket values, such as quality-of-life metrics, which impact health and wellbeing, social cohesion, etc., are not easily quantified.
- Idaho-specific data are limited; data could support Idahoans' health and Idaho's economy.
- Health practitioner training could include health risks of climate change, supporting Idahoans' health, reducing health care costs, and helping to maintain a strong economy.

1. Introduction: Impacts of Climate Change on Human Health and the Economy

Human health is significantly impacted by extreme weather-related events. Heat waves, floods, drought, and wildfires increase the risk of heat-related illness, respiratory illness, infectious diseases, mental health disorders, and even loss of life. Climate change will lead to more frequent and intense weather-related events in Idaho.

This report examines the impacts of climate change on Idahoans' health and the economy and is organized into five sections: (1) an overview of climate change impacts on health and related economic models and measures; (2) climate impacts on health and wellbeing from air pollution, temperature, allergens, water, vector-borne diseases, and more, as well as economic impacts, when possible; (3) populations most vulnerable to climate-related health impacts and potential economic impacts; (4) opportunities to prepare for climate impacts on health; and (5) summary.

1.1 Approach

This report was informed by international, national, state (including neighboring states), and tribal reports; current research and literature; and interviews with health care and public health organizations and institutions as to impacts of climate change on health and the economy. The authors interviewed many Idaho subject matter experts, spanning behavioral, social, environmental, and institutional impacts of climate change on health.

1.2 Limitations

Research on the impacts of climate change on health and wellbeing has grown steadily in the past decade. To our knowledge, an in-depth, Idaho-specific study of the impacts of climate change on health has not been completed. Assessing the economic impacts of climate change on health is a relatively new and complex area of research, which is supported by both measurement and health utilization and health outcome data (e.g., emergency room (ER) visits, hospital admissions; clinic visits, and emergency medical service (EMS) utilization). This report does not provide detailed economic impacts of climate change on Idahoans' health and the economy due to limited data availability, but does draw from research and findings in other states, regions, and nations.

1.3 Overview: Impacts of Climate Change on Health

Extreme weather events can impact human health. Climate-related events, including heat (Vaidyanatha et al., 2020; Ebi et al., 2021), wildfire smoke (Liu et al. 2015; Cascio, 2018; Holm, 2021), and poor air quality (Bell et al., 2007), are well-correlated with increased morbidity and mortality. Changes in climate also impact broader environmental health, which impacts human health in indirect ways that manifest over time. For example, climate changes can affect the survival, distribution, and behaviors of vectors that carry diseases like West Nile Virus or Lyme disease (Balbus et al., 2016), diminish water and food safety and quality, impact mental health, and disrupt wellbeing, social cohesion, and cultural traditions (U.S. Global Change Research Program (USGCRP, 2016)). The American Medical Association (AMA)'s Global Climate Change and Human Health policy indicates that climate change will "create conditions that affect public health, with disproportionate impacts on vulnerable populations, including children, the elderly, and the poor" (AMA, 2019).

The U.S. Centers for Disease Control and Prevention (CDC) offers the following model, Figure 1, to illustrate climate change impacts on health, such as extreme heat, air pollution, allergens, and potential health outcomes. This model is designed to be broad and not all climate exposures (e.g., rising sea levels) are pertinent to Idaho.

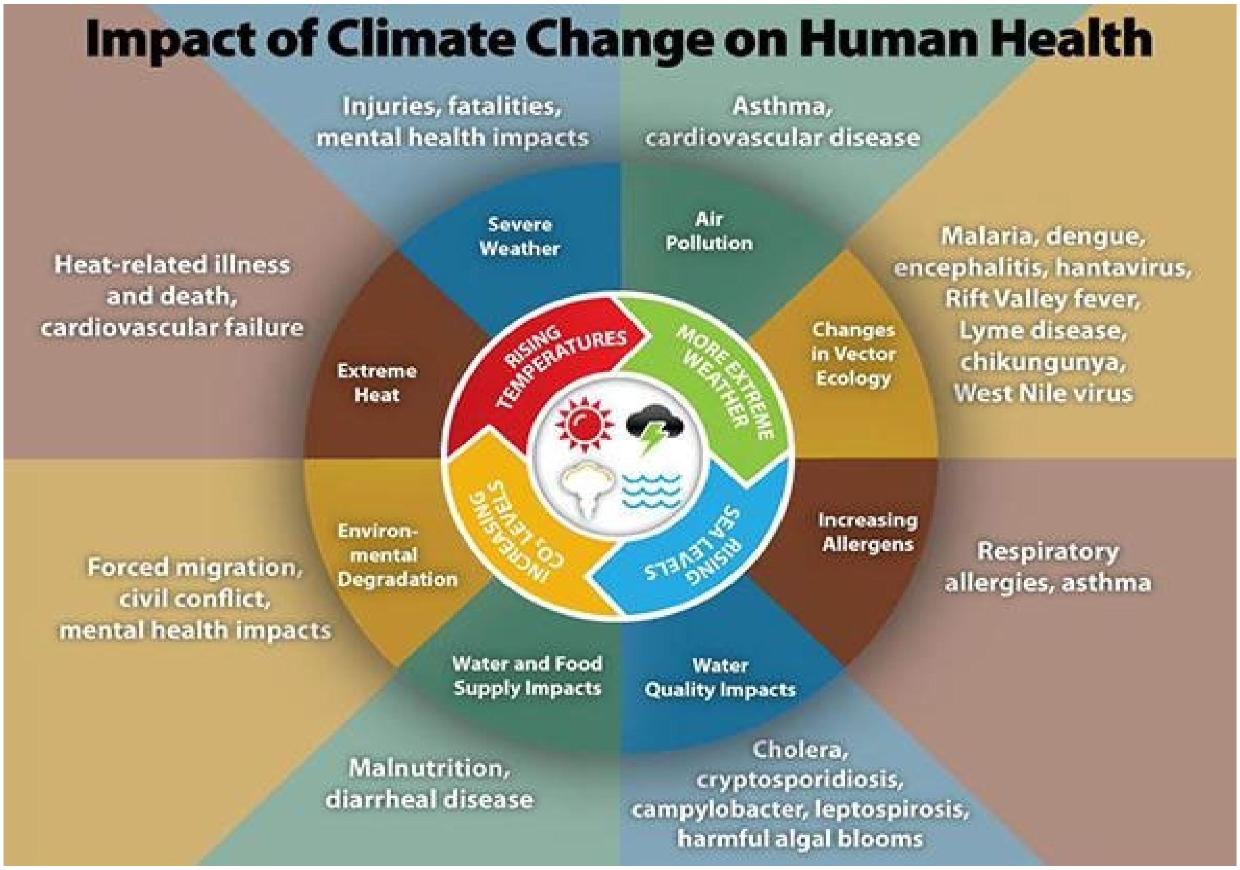

Figure 1. Impact of climate change on human health (CDC, 2021a).

The USGCRP (2016) developed a model of climate change exposure pathways to describe the effect of climate change on health. These exposure pathways differ over time, vary by location, and are based on contextual factors. Given exposure variation and duration, climate change affects people and communities differently, and to varying degrees of magnitude. The impacts of climate change exposure on an individual (e.g., disease, disability, injury, or death) is dependent on existing personal factors and conditions that, in turn, impact vulnerability. In the USGCRP, Balbus, et al. (2016) described vulnerability as the "tendency or predisposition to be adversely affected by climate-related health effects" and is encompassed by three elements: 1) exposure: contact between a person and biological, psychosocial, chemical, and/or physical stressors either in a single instance or repeatedly over time; 2) sensitivity: the degree to which people or communities are affected; and 3) adaptive capacity: the ability of communities, institutions, and people to adjust to potential hazards, also referred to as resilience.

Climate change exposure pathways may accumulate over time and lead to new, unanticipated health issues, worsen pre-existing health conditions, and negatively impact resilience, economic status, social connectedness, and mental health (Balbus et al., 2016). Impacts of climate change on health likely will impact local and regional health care systems, increase costs, and/or lead to the need to increase health care capacity (Cecre, 2009; Limaye et al., 2020).

To connect the impacts of climate change on human health exposures in Idaho, the Balbus model has been adapted by the authors (Figure 2). Pathways and magnitude of exposures are modulated by contextual factors that either positively or negatively influence health outcomes, depicted in the blue side boxes. The contextual factors that influence individual vulnerability are shown in the right-side box and reflect social determinants of health (Office of Disease Prevention and Health Promotion (ODPHP), 2021), individual health status, and behavioral choices. Contextual factors with large-scale impacts, such as the built and natural environment, governance, policy, readiness, and others, are shown in the left-side box.

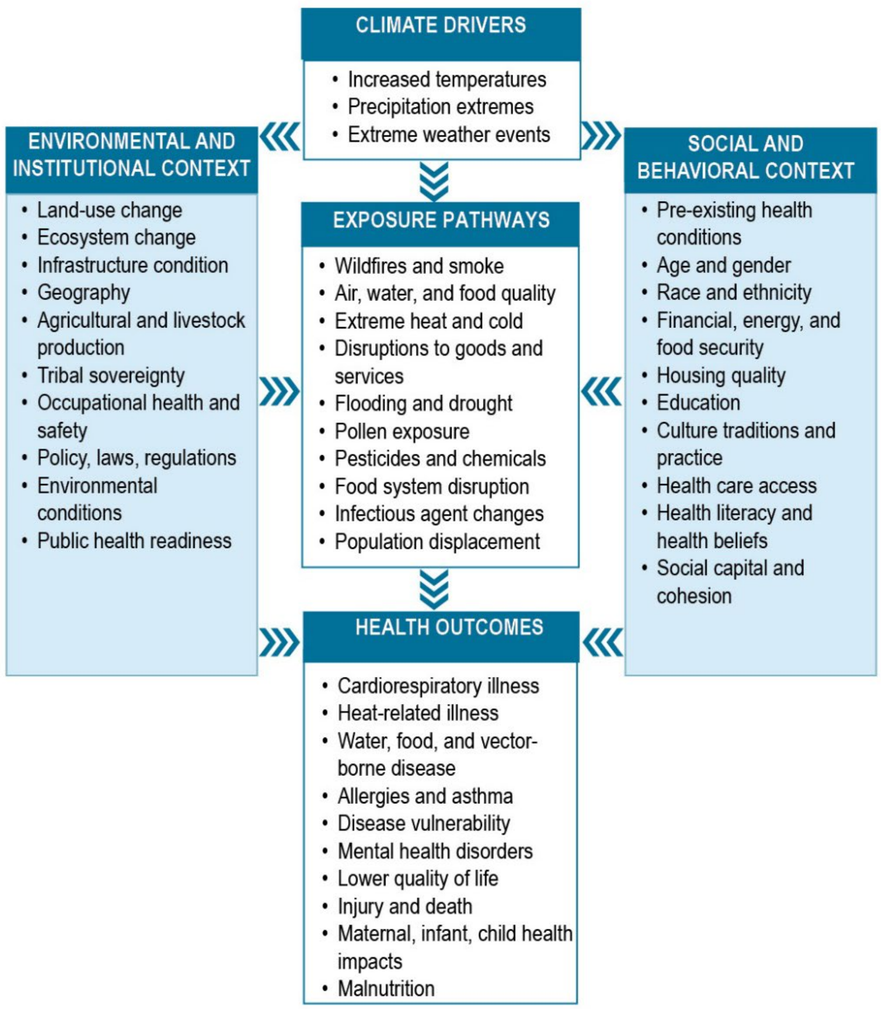

Figure 2. Model based on Balbus et al. (2016), which reflects current and potential climate change exposure pathways in Idaho. See Balbus Climate Change and Health model, p. 30.

1.4 Assessing Economic Impacts of Climate Change on Health

Research assessing the economic impacts of climate change on health is relatively new. Assessing economic impacts is challenging; while there are straightforward costs, such as medical costs of treatment and recovery from an occurrence or exacerbation (e.g., asthma from smoke exposure), these data are largely unavailable in Idaho. In addition, a myriad of economic dimensions weigh into cost impacts: medication and clinic visits, days lost from work or school, occupational impacts, emergency transport, emergency room visit costs, public health and social service response efforts, loss of life, and impacts to property, community, and social cohesion.

De Alwis and Limaye (2021) provide a framework for impacts of climate change on health care costs (summarized in Figure 3). Medical treatment and recovery from health conditions impacted by climate change adds economic burden to individuals, employers, insurers, medical providers, public health institutions, and health systems. Extreme weather events like heatwaves and wildfires can impact health systems, as people seek medical care, medicine, and other health-related services. Those seeking health care for climate-related illnesses and injuries may lose income and employers may experience loss from decreased productivity. The costs may continue to add up with ongoing treatment and medications.

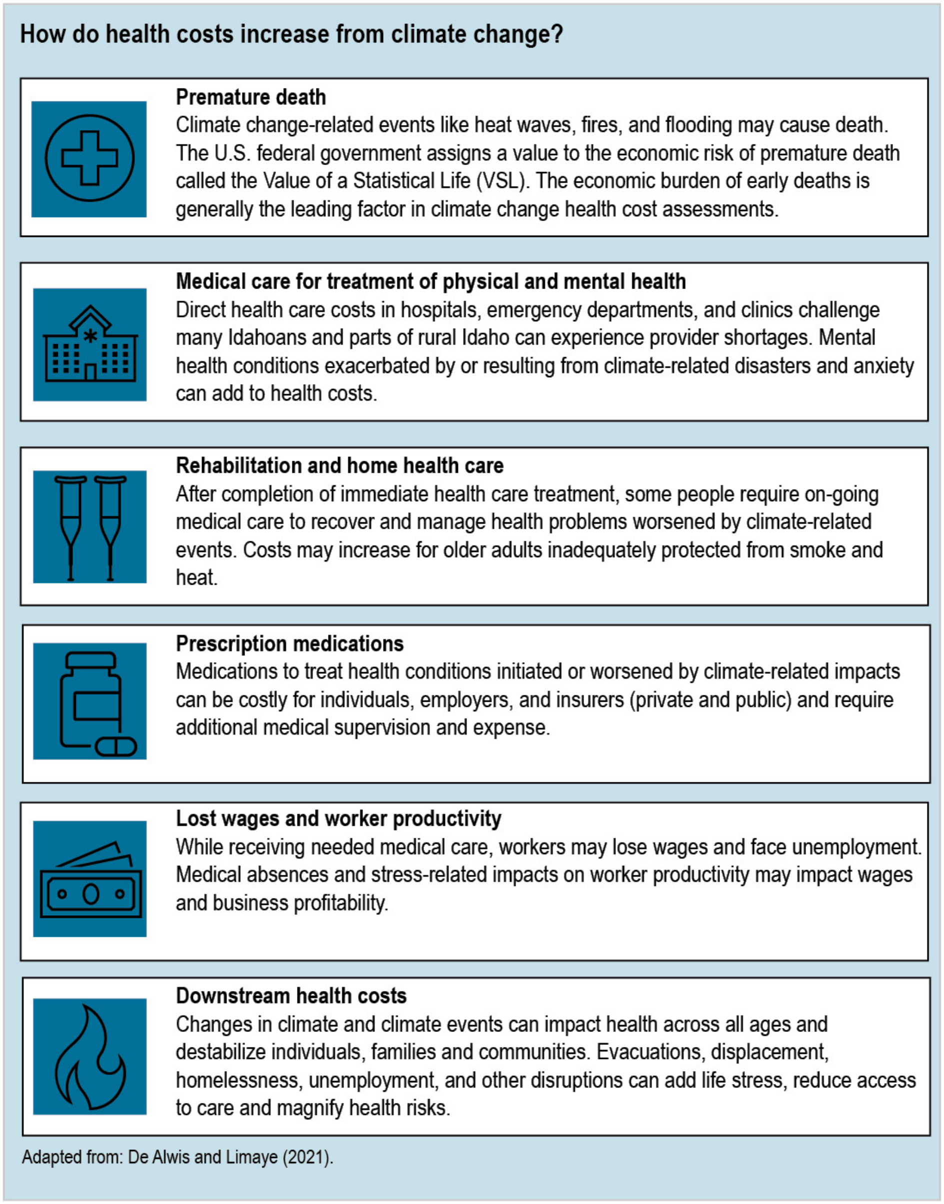

Figure 3. Health costs and climate change (adapted from De Alwis and Limaye, 2021).

De Alwis and Limaye (2021) assembled a series of studies and translated the results to 2020 U.S. dollars to estimate economic impacts of climate change on health costs. These results are presented in Table 1. Total annual costs were approximately $1.1 trillion. U.S. GDP in 2020 was approximately $21.0 trillion; total annual costs were equivalent to approximately 5% of U.S. GDP[1] (U.S. Bureau of Economic Analysis, 2021). Caveats to this analysis include: the studies reviewed covered different years, geographies, methodologies, and causalities. Also, many of the studies focused on regional example(s) of climate-related health costs and do not provide a comprehensive U.S. cost analysis. Despite these limitations, De Alwis and Limaye (2021) represents a plausible (likely upper-bound) order-of-magnitude

[1] Not all health-related costs are included in GDP. The purpose of this comparison is to provide an order-of-magnitude context.

of economic impacts of climate change on health costs. Estimations reported from the studies cited in Table 1 are sensitive to the methodologies employed in the studies, particularly the value of a statistical life (VSL) assumptions, nonmarket values, and the climate scenarios employed in the analyses.

Climate Event/Effect	Year/Study	Author	Billions (2020 USD)
$PM_{2.5}$ Air Pollution	2011	GoodKind et al.	$820.00
Extreme Heat	2012	Limaye et al.	$263.00
Wildfire Smoke	2010	Fann et al.	$16.00
Ground-Level Ozone (Smog)	2002	Knowlton et al.	$7.90
Hurricane Sandy	2012	Limaye et al.	$3.30
Lyme Disease	2008	Adrion et al.	$1.23
West Nile Virus (WNV)	2012	Limaye et al.	$1.10
Allergenic Oak Pollen	2010	Anenberg et al.	$0.01
Total			$1,112.5

Table 1: De Alwis and Limaye (2021). Analysis of the economic impacts of climate change on health costs.

Hsiang et al. (2017) cited macro-related U.S. studies that estimated costs of climate change between 1% and 3% of GDP annually. Their study was a bottom-up approach that estimated the costs of overall climate change at 1.2% of GDP for every 1°C increase in average temperatures (Hsiang et al., 2017). Risks and effects of climate change are expected to be spread unevenly across geographies in the U.S.

A series of complementary metrics are used to evaluate health-related costs and economic impacts of climate change on health. The following represents a brief overview of some (but not all) “value of a human life” economic methods of evaluation. These methods are used widely in the academic literature; each includes limitations. The same measures could be employed, as they are not presently, to assess economic impacts of climate change on health in Idaho.

There are several methods to valuing loss of life: human capital (productivity), value of a statistical life (VSL), quality-adjusted life year (QALY), and cost of illness (COI).

In the human capital, or productivity, approach, only an individual’s potential contribution to output as measured by the present value of lifetime earnings is counted towards the value of life. The value of a retired person under this approach would approach zero (Landefeld and Seskin, 1982). Using the U.S. Bureau of Labor Statistics (BLS) median U.S. salary of $41,954, the present value of lifetime earnings (PVLE) is $1,053,152 (with a 2.5% discount rate over 40 years in constant 2020 U.S. dollars). Using the BLS mean salary of $56,301, the PVLE is $1,413,537.[2] The human capital method limits the value of life to lost earnings and work life and does not include the value of leisure or enjoyment of life.

[2] The discount rate of 2.5% represents the real long-term bond rate and was utilized in Carnevale et. al. (2013).

Utilizing a VSL method implicitly broadens the economic value of life and represents a willingness to pay approach.[3] There is variation in the VSL estimates in the literature ($4-$10 million or higher). The U.S. Environmental Protection Agency (EPA) VSL metric is about $9.5 million (in 2020 U.S. dollars).

One limitation in the VSL approach is that it gives the young and old the same VSL value. There are several models that attempt to adjust for differences in age by annualizing VSL into a value of a statistical life year (VSLY) (Aldy and Viscusi, 2007). For the VSLY metric, VSL declines as age increases. Aldy and Viscusi (2007) found the VSL was not constant across age groups and represents an inverted U-shape across age-specific groups ranging from the young to the aged.

Quality-adjusted life year (QALY) is a value of life metric that includes a quality measure often used in new drug or treatment cost-effectiveness evaluation. Conover (2020) reported that the metric typically ranges from $100,000 to $150,000 per year of optimal health and declines with worsening quality of life outcomes. Applying a discount rate to the metric gives greater weight to early years of life gained and less weight to gain of life years later.

Cost of injury (COI), cost of illness, or burden of disease (BOD) is a broad-based frequently utilized analysis that encompasses many of the previously discussed metrics. It can be applied to any geography or scope, from international to local community, cohort, or individual. The analysis has three distinct components: 1) direct health care costs, which include all the treatment costs, from inpatient care to outpatient care, rehabilitation, nursing home, prevention services, and health education; 2) direct non-health care costs; and 3) indirect costs, which include loss of productivity, morbidity and mortality costs, lost leisure and family time, and other intangibles. Intangible costs are sometimes broken out and categorized separately.

2. Climate Change Impacts on Health

The following section focuses on environmental factors that impact human health. As the climate changes, these factors are expected to increase in severity and could expose more Idahoans to and/or increase the incidence rates of health impacts.

2.1 Air Quality

Two primary mechanisms contribute to poor air quality in Idaho: 1) air stagnation and inversions in the cold months keep local air pollutants within valleys and close to the ground, posing significant health challenges and 2) in warm months, wildfires in Idaho and surrounding states emit massive quantities of pollutants that dwarf all other sources of air pollution; see Figure 4 (Idaho Department of Environmental Quality (IDEQ), 2020).

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3 Viscusi (2005) gives an example of a group of people willing to pay $700 each to reduce the risk of death by 1/10,000. If 10,000 people are willing to pay $700 to reduce the chance of death by 1/10,000, then the value of a statistical life is $7 million. Alternatively, it can be calculated on a per unit (i.e., per person) basis; if a person is willing to pay $700 to reduce the risk of death by 1/10,000, then the implicit value of 1/10,000 of their life is $700. Multiplied by 10,000, one reaches the full VSL at $7 million (Viscusi, 2005).

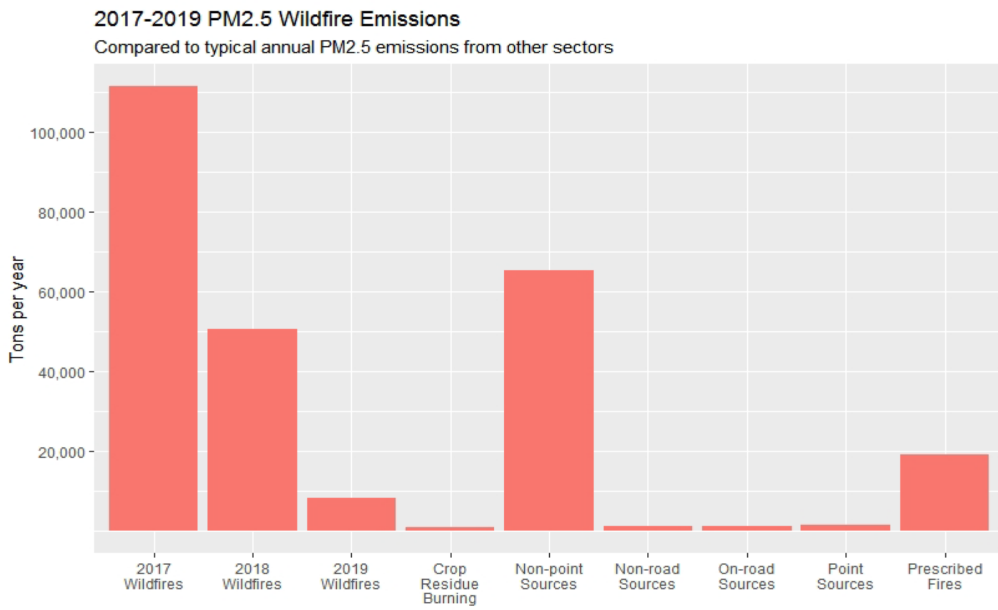

Figure 4. Wildfire-induced $PM_{2.5}$ emissions as compared to other sources in Idaho, 2017-2019 (source: IDEQ, 2020).

The primary air quality impacts for Idahoans stem from wildfire-induced particulate matter $(PM)_{2.5}$. In high wildfire activity years, wildfire-induced $PM_{2.5}$ is higher than all other sources combined. PM2.5 concentrations fluctuate from year-to-year, depending on location of wildfire, amount of smoke, wind direction, and other factors. The highest concentrations of $PM_{2.5}$ (from all sources) are observed in highly populated counties of southwest, central, and northern Idaho.[4] The relationship between climate change and poor air quality, as well as health impacts from poor air quality, is well-documented (Nolte et al., 2018). Only a few studies have measured the direct impacts of air quality on health in Idaho.

A study by Ulirisch et al. (2007) evaluated the effects of daily PM exposures (<10 mm in aerometric diameter, or PM_{10}) on respiratory and cardiovascular disease in Pocatello, Idaho and Chubbuck, Idaho from November 1994 through March 2000 by combining hospital admissions and medical visit (emergency room, urgent care, and family practice) data. Respiratory disease admissions and visits increased 7.1-15.4% per 50 µg/m^3 PM_{10} in each group analyzed, with the greatest increases in children and older adults (Ulirsch et al., 2007).

The Idaho Department of Health and Welfare (IDHW), Bureau of Community and Environmental Health conducted a preliminary study of PM levels and effects on cardiovascular and pulmonary diseases in northern Idaho. Health insurance data were collected from Blue Cross of Idaho, Regence Blue Shield of Idaho, and Medicaid. Medicare data were not collected, excluding adults aged 65 and over, along with the estimated 24% of Idahoans aged 18-64 who did not possess insurance at the time of the study. Hourly ambient air monitoring data were provided by IDEQ. The study found that increases of 10 µg/m^3 in $PM_{2.5}$ and of 50 µg/m^3 in PM_{10} were associated with increases of 11% and 33%, respectively, in acute stroke health care encounters. Increases of 50 µg/m^3 in PM_{10} were associated with increases in health care encounters for both acute lower respiratory illnesses and acute upper respiratory illnesses by 13% and

[4] See the assessment's Smoke Report for more information about air quality and smoke in Idaho.

10%, respectively. Increases of 50 μg/m^3 in PM_{10} were associated with a 27% increase in chronic cardiac illness health care encounters (Vannoy et al., 2006). These findings are consistent with studies conducted at the local, state, and country levels (e.g., Lee et al., 2018; Wettstein et al., 2018).

Smoke[5,6]

The frequency, intensity, and size of wildfires continues on an upward trend as the climate becomes warmer and drier in the western U.S. (Reid et al., 2016). Assuming these trends remain consistent, communities in the northwestern U.S. that are downwind from wildfire impacted areas can expect major episodic wildfire smoke exposures during future wildfire seasons (Liu et al., 2016). Peer-reviewed literature on health impacts of wildfire smoke is limited, but growing; researchers often extrapolate from urban or ambient air pollution studies to assess risk. Such extrapolations can be limited, given that toxicity depends on air pollution constituents and characteristics, which can vary greatly by source (e.g., traffic-related pollution vs. wildfire smoke pollution) (Black et al., 2017). Moreover, wildfire smoke health data available tend to focus on cardiopulmonary impacts; however, a growing body of literature[7] suggests extra-pulmonary effects, including the impacts of chronic wildfire smoke exposure on neurocognitive (Schuller and Montrose, 2020) and reproductive health (Reid et al., 2016; Sosedova et al., 2021).

In the northwest, wildfire smoke is leading to increases in the yearly average of $PM_{2.5}$ (McClure and Jaffe, 2018). Among wildfire smoke constituents, which can include carbon monoxide, volatile organic compounds, and hydrocarbons, PM is the most abundant individual pollutant by mass (Zelikoff et al., 2002). $PM_{2.5}$ is of particular concern for public health because this size fraction can reach the deep lung area where gas exchange occurs (Darquenne, 2012). Besides being small, the source of particle generation (e.g., grass, brush, trees); the nature of the combustion (e.g., flaming, smoldering) (Kim et al., 2018); and the process of particle aging (i.e., interactions with other chemicals to form secondary products) pose significant health impacts (Wong et al., 2019). The latter factor is especially pertinent, given that these small particles can travel hundreds and even thousands of miles from the source of combustion (Kollanus et al., 2016; Reid and Maestas, 2019). Recent research has found that smoke can contain living bacteria and fungi (Kobziar and Thompson, 2020).

The human body can defend against some respirable air pollutants, but not all. Where larger particles deposit in the nasal cavity or get trapped in the mucous that lines the upper respiratory tract, $PM_{2.5}$ particles can bypass these defense mechanisms (Darquenne, 2012). In the lung alveolar space, macrophages, part of the immune system, seek out, consume, and destroy foreign invaders, including

[5] Section contribution by Luke Montrose, Assistant Professor, Public Health and Population Science, Boise State University and Mojtaba Sadegh, Assistant Professor, Civil Engineering, Boise State University.
[6] Other wildfire-related impacts on human health include PFAS (Per- and Polyfluoroalkyl Substances). PFAS is a group of human-made chemicals that may be harmful to humans and could increase risk of certain cancers and disease (EPA, 2016a). PFAS is found in many products, including firefighting foam (Dauchy et al., 2017). The most common path of exposure to PFAS is through contaminated soil used to grow food or drinking water (EPA, 2016a). The use of PFAS firefighting foam may be of concern, particularly if wildfires in Idaho increase in number and/or intensity with climate change. Although PFAS substances are no longer manufactured in the U.S., and some states have restricted the use of firefighting foams containing PFAS, such foam can still be used for firefighting in Idaho (EPA 2016a; Sokol, 2020; IDEQ, 2021a).
[7] See the Montana Climate Assessment (Adams et al., 2021) for additional studies on smoke risks that could impact Idahoans.

viruses, bacteria, and air pollutants, such as $PM_{2.5}$ (Migliaccio et al., 2013). Upon interacting with the $PM_{2.5}$ (and the surface markers on the particle), macrophages may release signals that stimulate an adaptive immune response. On its own, this signal cascade can be helpful to the body; however, an overreactive immune cascade, or one that remains chronically turned on (perhaps due to repeated exposure), can lead to long-term lung damage in the form of fibrosis (Warheit-Niemi et al., 2019). This damage can impact the elasticity of the lung and reduce the volume of oxygen that gets into circulation. An adaptive immune response induced by $PM_{2.5}$ can be problematic in individuals who have preexisting lung conditions, such as asthma or chronic obstructive pulmonary disease (COPD) (Tiotiu et al., 2020).

The effects of $PM_{2.5}$ on the body's immune system may have additional health impacts. Studies have demonstrated that repeated exposure to wildfire smoke can deplete the number of macrophages that reside in the deep-lung area, leaving the immune system less equipped to defend against invasive foreign bodies (Samuelsen et al., 2009; Migliaccio et al., 2013). Recent human epidemiological studies appear consistent with results from animal models. Researchers in Montana examined 10 years of wildfire season data and found that following extreme smoke years, the number of influenza cases were higher, supporting the hypothesis that $PM_{2.5}$ in the lung hinders the immune system's ability to resist foreign bodies that can cause lung infections (Landguth et al., 2020). The health effects of wildfire smoke-generated $PM_{2.5}$ may damage other organs. More recent data are beginning to point toward extra-pulmonary organ effects, as well as impacts on fertility, birth outcomes, mental health, and neurocognitive function (Reid et al., 2016; Willson et al., 2019; Nelson, 2020; Schuller and Montrose, 2020).

U.S. EPA regulates outdoor particulate levels (PM_{10} and $PM_{2.5}$) as part of the National Ambient Air Quality Standards (NAAQS) (EPA, 2021a). However, neither the EPA nor the National Institute of Occupational Safety and Health (NIOSH) nor Occupational Safety and Health Administration (OSHA) currently regulate these levels in indoor spaces, including hospitals, schools, and long-term care facilities.

Economic Impacts of Smoke and Poor Air Quality on Human Health

Economic studies of wildfire smoke differ in terms of which direct and indirect costs (including intangible costs) are incorporated into each analysis. Fann et al. (2018) found that from 2008 to 2012, western wildfire smoke hospitalized an estimated 5,200 to 8,500 people, with an estimated 300 to 500 deaths. They used a cost of illness methodology and employed a VSL of $10.1 million (likely an upper-bound estimate). The cost of hospitalization and lost earnings was estimated at $36,000. Fann et al. (2018) found the cost of short-term smoke exposures to be $11-$20 billion per year, measured in 2010 U.S. dollars. Long-term exposure costs were estimated to be $76-$130 billion per year, measured in 2010 U.S. dollars (Fann et al., 2018). Various willingness to pay studies found that individuals were willing to pay $36-$129 per day to avoid various smoke-related symptoms (see assessment's Smoke Report). Employing a wider range of intangible costs, Jones (2017) found individuals were willing to pay $373 to avoid one day of smoke over a 6-month period. A recent report concluded that the direct health costs of air pollution and climate change in the U.S. exceed $800 billion per year and are anticipated to increase as temperatures rise (De Alwis and Limaye, 2021). This cost estimate does not include other health-related costs presented in USGCRP (2016), such as contamination of food and water, disruption of essential supply chains, economic hardship, long-term health consequences, reduced quality of life, mental health impacts, and others.

While outdoor air quality data are readily available, data from hospital admissions; medical visits (emergency room, urgent care, family practice); and health care utilization are needed to assess economic impacts of wildfire smoke and outdoor air quality on health in Idaho.

2.2 Extreme Heat[8]

Extreme heat events are projected to become more common, more severe, and last longer in Idaho, with more extreme heat events in areas that have not historically experienced extreme heat. Areas in Idaho that currently experience extreme heat days are projected to experience extreme heat more often (see assesment's Climate Report). Figure 5 displays the projected change in number of 100°F+ heat index[9] days, comparing the historical period, 1971-2000, and mid-century, 2040-2069 (RCP8.5).[10] Heat-related health impacts occur well below 100°F (Gao et al., 2018). See the assessment's Climate Report for more information on extreme heat projections. Associations between extreme heat events and human health present challenges because of lack of uniform definitions and standards, variations in social factors impacting heat acclimatization and exposure, inconsistent and incomplete reporting of health-related illness and injury, and other factors (Smith et al., 2013).

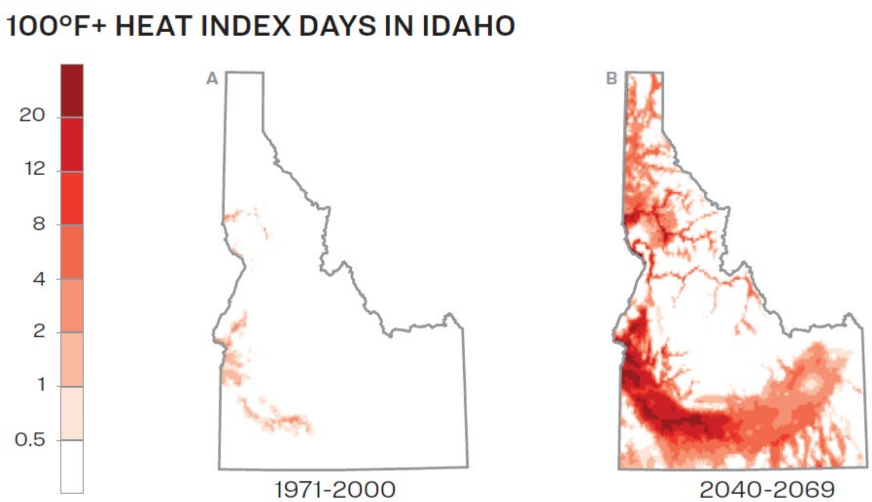

Figure 5. Projected change in 100°F+ heat index days in Idaho, comparing historic (1970-2000) and mid-century (2040-2069), RCP8.5 (from the assessment's Climate Report).

Health effects from extreme heat (heat-related illnesses) follow a continuum from mild to life threatening, including heat rash, heat syncope, heat cramps, heat exhaustion, and heat stroke, which can be fatal. In

[8] The EPA defines extreme heat as summertime temperatures that are much hotter and/or humid than average for a particular location (EPA, 2016b).
[9] The heat index, also known as apparent temperature, is what the temperature feels like to the human body when relative humidity is combined with the air temperature (NOAA, n.d.).
[10] Representative Concentration Pathways (RCPs) are emission scenarios. RCP4.5 is a moderate-warming scenario and RCP8.5 is a high-warming scenario. Mid-century projections are less sensitive to choice of RCP; differences between RCP4.5 and RCP8.5 are most important for late century projections (see the assessment's Climate Report for more information).

addition, extreme temperatures have a direct linkage to atmospheric ozone concentrations, resulting in poor air quality, adding to the health risks of extreme heat exposure (EPA, 2021b; Schwarz et al., 2021).

Brief and slight temperature increases above seasonal norms can result in heat-related illness and death, especially when temperature increases occur early in the season before people have adapted to rising temperatures (Abbinett et al., 2020). A 1°F increase in average mean temperature during a heat wave in the northeast was associated with a 4.39% increase in the relative risk of mortality (Popovich and Choi-Schagrin, 2021). The duration of the heat wave was associated as well; mortality risk increased on average by 2.5% for every extra day a heat wave lasted (Anderson and Bell, 2011). Elevated nighttime temperatures pose additional health risks during heat wave events when people are unable to recover during the night from the daytime physiological stress.

Heat-related illness encounters are concentrated during the summer months. Analysis of data from the National Syndromic Surveillance Program (NSSP) revealed that 79% (2,779) of the 3,504 heat-related illness emergency department visits from May 1 to June 30, 2021 in the U.S. Department of Health and Human Services (HHS) Region 10 (which includes Alaska, Idaho, Oregon, and Washington) occurred over 6 days (June 25-30), when most of Oregon and Washington were under an excessive heat warning (Schramm et al., 2021). The data were reported for the entire HHS Region 10; data specific for Idaho heat-related illness emergency department visits were not available.

Extreme heat events are one of the leading causes of weather-related deaths in the U.S. (CDC, 2020a); weather-related deaths can be preventable (Ready.gov, 2021). Between 2004 and 2018, a total of 10,527 deaths resulted from exposure to heat-related conditions; an average of 702 health-related deaths (415 with heat as the underlying cause and 287 as a contributing cause) occurred each year in the U.S. The number of deaths associated with extreme heat events may be under-reported; extreme heat may not be identified by a medical examiner and/or not properly coded on the death certificate (Vaidyanathan et al., 2020). It was estimated that more than 1,300 deaths per year in the U.S. were due to extreme heat, compared to the 600 deaths per year reported (Sarofim et al., 2016). Models of high-warming scenarios predict that U.S. heat-related deaths from 2031 to 2050 will be 57% higher than 1971-2000 (Dahl et al., 2019).

Extreme Urban Heat

Negative effects of extreme heat are and will continue to be most pronounced in urban areas among populations most exposed and sensitive to heat and with less capacity to adapt to heat stressors (Voelkel et al., 2018). Urban areas with highly concentrated structures (buildings, roads, and other infrastructure) and limited greenery become "islands" of higher temperatures relative to outlying areas (EPA, 2020). The urban heat island (UHI) effect has been found to result in increases in daytime temperatures about 1-7°F and nighttime temperatures about 2-5°F higher than areas with less concentrated structures. The UHI effect is predicted to increase as the structural and population density of urban areas increase (Hibbard et al., 2017) and is exacerbated by higher frequency and longer duration of extreme heat events.

High Indoor Heat

Heat waves may result in higher temperatures indoors compared to outdoors in housing without adequate cooling, insulation, and shade; high indoor heat can remain days after the end of the heat wave (White-Newsome et al., 2012). A recent review of published literature found that high indoor heat (defined as above 78.8°F) resulted in increased calls made to paramedics for respiratory distress, exacerbated symptoms of schizophrenia and dementia, and increased absorption of insulin among people with Type 1 diabetes, impacting blood sugar regulation (Tham et al., 2020). Research on the impact of high indoor heat is emerging and there is no identified "maximum acceptable temperature" presently. Power disruptions from wildfire, storms, and energy demands during heat waves can have direct and indirect impacts on health. These impacts are greatest for individuals with temperature sensitive chronic conditions, such as diabetes, and pose risks for those reliant on energy-powered life-saving and supporting medical devices.

2.3 Allergens

Rising temperatures, as expected in Idaho, lead to longer allergy seasons and can worsen air quality. This can increase the risk and severity of asthma attacks and can cause more allergies (Asthma and Allergy Foundation of America, 2010). Exposure to outdoor allergens is associated with exacerbations of upper and lower respiratory allergic disease (Baldacci et al., 2015). Higher CO_2 levels, warmer temperatures, and later frosts increase pollen production, especially in urban areas. Allergen triggers, primarily ragweed, are able to grow longer, faster, produce more pollen, and have higher allergenic content (Ziska and Caulfield, 2000; Anderegg et al., 2021). These impacts are amplified in urban areas where buildings, roads, and other infrastructure increase temperature and vehicles and industries produce more CO_2 than in areas outside of cities (Staudt et al., 2010). Warmer temperatures also allow for the expansion of allergenic tree species (Ziska, 2021). Airborne allergens exacerbate asthma attacks and include cascading effects, such as reduced physical and mental health, poor sleep quality, decreased worker productivity, physical activity limitations, absenteeism and lower achievement among students, and higher health care expenditures (Poole et al., 2019).

2.4 Drought

Idaho is expected to experience greater periods of drought and less time between drought events (see assessment's Climate Report). Drought is associated with a myriad of direct and indirect impacts to health, such as infectious diseases, food insecurity, economic loss, stress, and mental health effects (Stanke et al., 2013). Populations reliant on agriculture and those that experience economic loss due to drought are most at risk for adverse mental health effects (O'Brien et al., 2014). Long-term public health challenges related to drought include drinking water shortages, diminished water quality, impacts to sanitation and hygiene, and reductions in air quality (Sugg et al., 2020). Risk of West Nile Virus increases as stagnant water from reduced streamflow during drought events provides mosquito habitat (Paz, 2019). While drought is a broad geographic exposure, impacts vary depending on the social determinants of health, such as occupation, education, health care access, and health and mental health conditions (CDC, 2020c; Lookadoo and Bell, 2020).

Recent research identifies and links drought impacts to drought severity across U.S. states; however, drought-related health impacts are not identified (Noel et al., 2020). To our knowledge, no research exists on drought and health in Idaho. A study from California in the fourth year of the most severe drought on record described drought-related health impacts. Households in the two most drought-stricken counties reported a range of drought-related health impacts, including increased dust leading to allergies, asthma, and other respiratory issues, as well as acute stress and diminished peace of mind (Ebi et al., 2018). These health effects were not evenly distributed; an increased number of negative physical and mental health impacts were reported when drought negatively affected household property and finances (Ebi et al., 2018). For more information on drought, see the assessment's Water Report.

2.5 Harmful Algal Blooms (HABs)[11]

Harmful Algal Blooms (HABs) describe the rapid growth of potentially dangerous cyanobacteria, also known as blue-green algae (CDC, 2018). While small amounts of cyanobacteria exist in most freshwater bodies across Idaho, cyanobacteria only become dangerous when populations boom and large quantities of cyanotoxins are produced (IDEQ, 2021b). Human and animal exposure to these toxins through direct water contact, inhalation, or ingestion can lead to illnesses and symptoms ranging from mild irritation to seizures, and even death in extreme cases (USGS, 2016; Roberts et al., 2020). HABs are most common in the summer months when water temperatures are at their warmest. Higher ambient air temperatures will increase average water temperature, while changes in rainfall patterns can lead to higher nutrient runoff into bodies of water, as well as decreased flow in the summer months, each of which promote faster cyanobacteria growth (EPA, 2013) (see Figure 6).

[11] Section contribution by Sam Holownia, undergraduate student, University of Idaho.

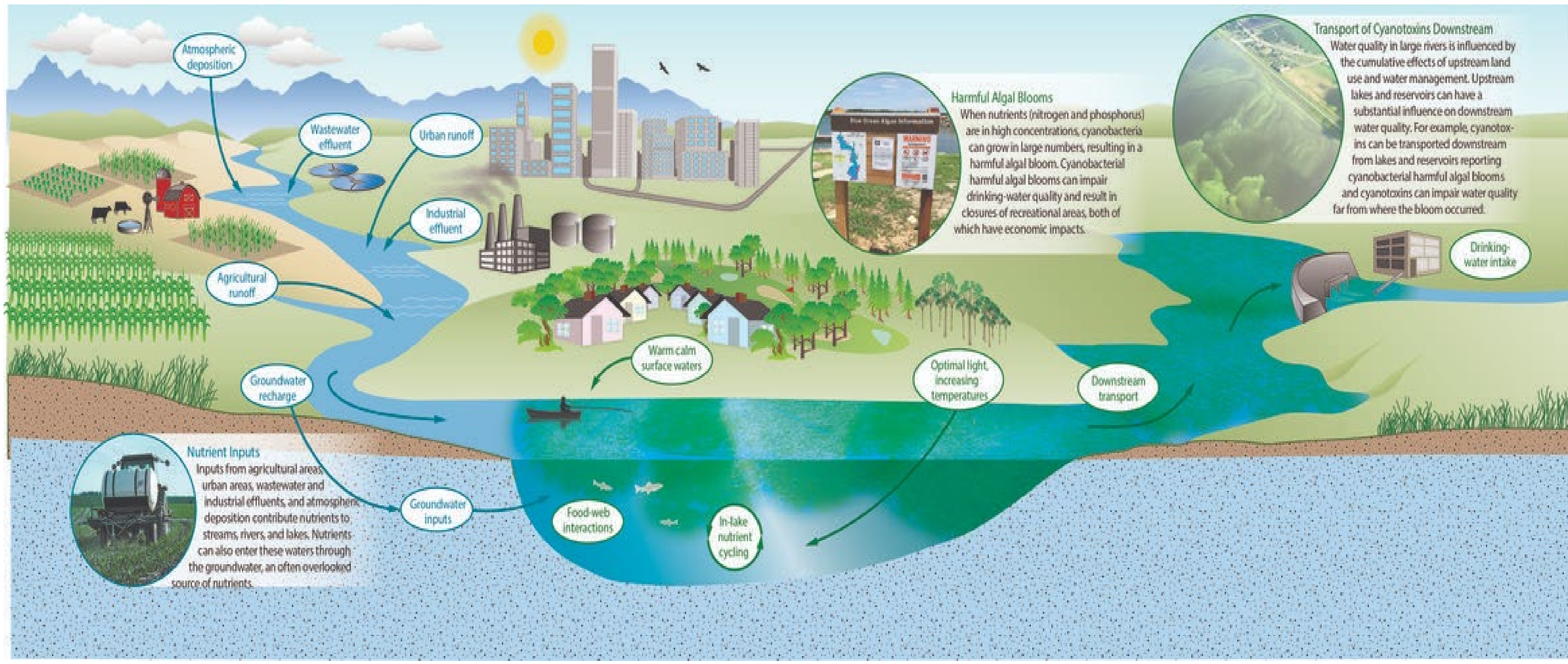

Figure 6. Illustration of common factors that contribute to HABs (USGS, 2016).

IDEQ currently relies on public reporting of potential blooms before investigating and issuing a Recreation Water Health Advisory, if necessary (IDEQ, 2021b). However, early detection of HABs has the potential to reduce economic impacts by alerting people to reduce contact with the water bodies that have HABs and therefore avoiding the associated health care expenses. In a recent study, researchers compared the use of satellite imagery to detect a bloom in Utah Lake in 2017 with a scenario that did not incorporate early detection. Early detection (about 7 days sooner than other methods) led to potential savings of approximately $370,000 (measured by medical visits, ER visits, hospitalization, and loss of productivity from missed work days) from reductions in HAB exposure and cases of gastrointestinal illnesses with mild to severe symptoms (vomiting, diarrhea, nausea, and abdominal pain) (Stroming et al., 2020). HABs also can result in decreased property value, loss in recreational revenue, increased cost of drinking water treatment, and impacts to ecosystems (USGS, 2016). There are currently no known estimates of economic costs related to HABs in Idaho.

2.6 Vector-Borne Diseases[12]

Climate change is expected to alter the geographic and seasonal distributions of vector-borne diseases and their vectors, such as ticks and mosquitos (Rocklöv and Dubrow, 2020). These changes will result in northward range expansions of ticks in response to increasing temperatures and influence the prevalence, abundance, and distribution of mosquitos (Beard et al., 2016). This will result in vector-borne disease exposure in previously non-vector-borne disease areas and/or an increase in disease, leading to possible additional health costs and an increased need for vector control measures in Idaho (Beard et al., 2016). Current and future costs associated with vector-borne diseases in Idaho may be larger than expected due to underreporting and lack of routine vector and vector-borne disease surveillance (Hinckley et al., 2014).

Tick Vectors

Idaho's most prevalent tick-borne disease is Spotted Fever Rickettsiosis, also known as Rocky Mountain Spotted Fever (RMSF) (CDC, 2020d). The western blacklegged tick that carries Lyme disease and the Rocky Mountain wood tick that carries RMSF also are found in Idaho. The Panhandle area of Idaho saw six cases of RMSF between 2018 and 2020; while a seemingly small number, each case can cause considerable damage (Hoyer, 2020). With prolonged warmer weather, these tick types are able to increase their reproductive ability, grow more rapidly, and expand in Idaho (Colarossi, 2020). Figures 7 and 8 show rates of incidences of Lyme disease and RMSF in Idaho.

Lyme disease is responsible for $2,968 more in annual health care costs per effected person and a greater number of outpatient visits that also result in higher costs, compared to a more easily treatable infection (Adrion et al., 2015). High costs are associated with RMSF due to its severe side effects, particularly when treatment does not occur before the fifth day of symptom onset (Drexler et al., 2015). Economic costs were evaluated for an outbreak of RMSF on tribal lands in Arizona during the period 2002-2011 (Drexler et al., 2015). There were 205 reported infections, which cost $1,371,870 in acute medical care, and of these reported infections, 29 people were admitted to the ICU and 15 died (Drexler et al. 2015). Total cost of RMSF on the two tribal reservations in Arizona was estimated at $13,200,000 during the period 2002-2011 (Drexler et al., 2015).

[12] Section contribution by Sierra Brantz, undergraduate student, University of Idaho.

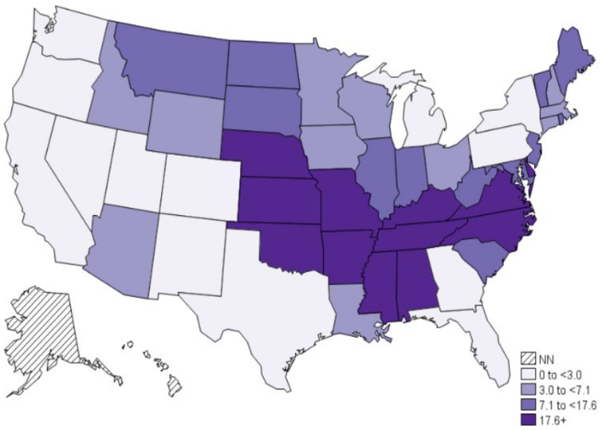

Figure 7: Annual Incidence of Spotted Fever Rickettsiosis cases per one million people in the U.S. in 2018. [Epidemiology and Statistics | Rocky Mountain Spotted Fever (RMSF) | CDC]

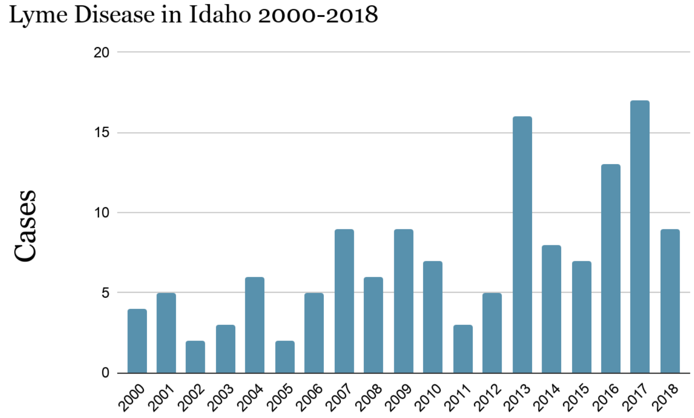

Figure 8: Lyme disease incidence for Idaho by year, 2000-2018. *[Lyme disease surveillance and available data | Lyme Disease | CDC]*. Based on CDC Excel spreadsheet.

Mosquito Vectors

The mosquito species *Culex tarsalis* and *Culex pipiens* that spread West Nile Virus (WNV) are in Idaho. WNV was first detected in Idaho in 2003, after arriving on alligators that had been imported to Idaho from Florida (IDHW, 2020). In 2004, the first report of local (mosquito-borne) transmission was reported, the first year WNV became reportable in Idaho (IDHW, 2020). Between 2003 and 2019, 1,382 human cases of WNV (imported and locally-acquired) were reported in Idaho (IDHW, 2020). Human cases per year typically have been less than 50, with the exception of 2006, when 996 human cases were reported (IDHW, 2020). Increased incidence WNV has been seen with milder winters and increased temperatures and studies suggest mosquito expansion in higher elevations and northern latitudes in response to climate change (Hahn et al., 2015; Beard et al., 2016). Mosquito activity is an important factor when looking at WNV, which has a period of amplification in bird reservoir populations,[13] and could result in increased biting rates (Brown et al., 2015). Mosquito control and abatement[14] could increase in cost with climate change. For example, a 2005 outbreak in California resulted in 163 human cases of WNV, with a cost of $2.98 million related to increased costs of vector control spray, medical treatment of WNV disease, and other economic impacts (Barber et. al, 2010).

2.7 Climate Change and Mental Health[15]

Extreme weather events impact acute and chronic mental health (USGCRP, 2016). Individuals exposed to extreme weather events may have temporal mental health impacts, such as stress, trauma, shock, grief, and distress. Extreme weather exposures can lead to major clinical disorders, substance use disorders, post-traumatic stress disorder (PTSD), and suicidal ideation (Staudt et al., 2010) and attempt (Burke et al., 2018; Di Nicola et al., 2020; Aguglia et al., 2021). A systematic review of studies on heat exposure and

[13] A bird reservoir population is a type of natural reservoir, also known as a disease reservoir or a reservoir of infection, in which an infectious pathogen naturally lives and reproduces, or upon which the pathogen primarily depends for its survival.
[14] Infection rates have been managed through Integrated Pest Management (IPM) and surveillance that removes mosquito habitat, uses structural barriers, and controls the mosquitos at both larval and adult stages (EPA, 2016).
[15] Portions of this section provided by Kat Davis, Sustainability Director, Boise State University.

mental health outcomes found an increase in mood disorders, organic mental disorders, schizophrenia, and anxiety disorders during heat events (Liu et al., 2021). The highest effect for mental health morbidity was observed when heat waves were defined as mean temperature equal or greater to the 90th percentile for 3 or more days (Liu et al., 2021). Climate change also may result in displacement of communities, destruction of cultural sites, loss of livelihood, and increased impacts of heat, drought, and food insecurity, resulting in direct and indirect risks to psychological health (Doherty and Clayton, 2011). Extreme weather events are expected to increase in Idaho (see the assessment's Climate Report and Infrastructure Report).

Stress of anticipating future losses and risks to wellbeing result in moderate to extreme anxiety about climate change, known as climate anxiety (Gifford and Gifford, 2016). Gifford and Gifford (2016) described mental health effects of anticipating a future of climate change, as well as effects of extreme weather events, as causing pre-traumatic stress disorder. As wildfires, floods, and storms increase in frequency and severity, individuals also may experience a sense of ecological grief and loss of identity (Comtesse et al., 2021). Cunsolo and Ellis (2018) define ecological grief, or "eco-grief" as "felt in relation to experienced or anticipated ecological losses, including the loss of species, ecosystems, and meaningful landscapes due to acute or chronic environmental change" (Cunsolo and Ellis, 2018, p. 275).

Although the impacts of climate change on anxiety, stress, and other mental health disorders have not been studied specifically in Idaho, University of Idaho researchers have surveyed Idahoans in regard to emotions related to climate change (Haltinner et al., 2021). While climate anxiety can impact all ages and backgrounds, climate anxiety among individuals born after 1990 is unprecedented. Ray (2020) called this group the "climate generation" (p. 3). Described as those born in the early 1990s through the 2000s, Ray identified this group as the first generation to grow up with the effects of climate change as a present issue rather than a future problem (Ray, 2020). Fear, helplessness, depression, anxiety, and shame have been identified as aspects of climate anxiety in this age group (Fritze et al., 2008).

2.9 Infrastructure and Health

Idaho has 9 urban counties (a population center of 20,000 or more), 19 rural counties (6 persons per square mile without a population center of 20,000 or more), and 16 frontier counties with less than 6 persons per square mile. In parts of the state, some residents may be located hours from health care facilities, which themselves, may be rural (IDHW, 2021). In addition, patients with health care emergencies can be 5-6 hours away from major urban hospitals by ambulance. Winter conditions make many of these roads challenging. Extreme weather events likely will add to these challenges. Other infrastructure difficulties include ensuring access to basic supplies, such as groceries, medical supplies, home heating fuel, etc., that could be interrupted during an extreme weather event. For more on infrastructure impacts, see the assessment's Infrastructure Report.

2.10 Food Security

Climate change is likely to affect global, regional, and local food security[16] by disrupting food availability, decreasing access to food, and impacting food utilization (Brown et al., 2015). Extreme

[16] As defined by USDA Economic Research Service, food security is access by all people at all times to enough food for an active, healthy life (USDA ERS, 2021).

weather events can lead to food insecurity and food safety issues, with impacts to food production, processing, distribution, storage, and food access, as well as water. Climate change exposures may multiply food insecurity among individuals who are displaced, lose jobs, pregnant, in poverty, rely on subsistence food sources, and lack access to food sharing or emergency food sources (Brown et al., 2015). As described in the following case study, impacts on the food system in Idaho and across the nation and increased reliance on emergency food highlight the opportunity for greater preparedness related to food security resilience in Idaho.

Food Security: COVID-19 and the Idaho Food Bank

The COVID-19 pandemic illuminated vulnerability within Idaho's food system. During the height of the COVID-19 shutdown (March-April 2020), the Idaho Food Bank, serving 465 community food distribution partners, transitioned quickly to prepackaged food box distribution and drive-through models to meet the 60% increase in demand for food. Of that, 20-30% of the demand was from new clients. The increased demand resulted in the need to purchase a historic amount of food—five times the annual budget. The epicenter of the pandemic, Blaine County, experienced a 300% increase in demand for food as a result of sudden unemployment for tourist-dependent workers. Major food supply chain disruptions and panic food buying across the U.S. resulted in a 35% reduction in Idaho Food Bank donations from local grocery stores. The Idaho Food Bank faced an additional challenge: finding adequate storage to meet the increased food demands once supply chains returned to near-normal operations. While demand for subsidized food was growing significantly, disruptions caused a considerable amount of local food to go unharvested and be wasted, further reducing food available for distribution in Idaho and neighboring states (Idaho Food Bank, 2021).

3. Climate Change Impacts on the Health of Vulnerable Populations

The populations included in this section are sensitive to the environmental factors discussed in the previous section. However, vulnerability may be more pronounced with increases in environmental factors associated with climate. Vulnerability to climate change-related health impacts is dependent on the magnitude, frequency, duration of exposure; where the event occurs; sensitivity of the individuals and collective community exposed; and capacity of the individual and community to adapt to climate impacts (Smit and Wandel, 2006). Some populations face greater exposure and have less adaptive capacity (Leichenko and O'Brien, 2008). Populations that are socially marginalized, poor, and face health disparities are disproportionately impacted (EPA, 2021c). These groups are the most exposed, most sensitive, and have the least individual and community resources to plan for, prepare for, and respond to climate-related exposures that can impact health (Ebi et al., 2018).[17]

[17] The CDC created the Social Vulnerability Index (SVI) as a quantitative measure of the social conditions that impact a community's ability to assess, plan, and prepare for hazardous events, disease outbreaks, and climate-related events. The SVI offers one way to assess county and state susceptibility to hazards, including climate change. The 17 SVI indicators are grouped into four overarching themes: socioeconomic status, household composition and disability, minority status and language, and housing type and transportation

3.1 Older Adults

Older adults can have unique vulnerabilities to extreme heat events, heat waves, poor air quality, and other climate exposures due to pre-existing health conditions, mobility limitations, cognitive disabilities, reliance on electronic medical devices, and social or geographic isolation (Balbus and Malina, 2009; EPA, 2021c). These factors can inhibit older adults' ability to access medical attention, heat or cooling refuge centers, and social support; this is particularly true for older adults living alone and in rural areas (Rhoades et al., 2018).

Older adults may face climate-related health risks, particularly those lacking air-conditioning during extreme heat or that lose cooling, heating, or air filtration due to power outages (Kovats and Hajat, 2008). Research suggests that evacuation of nursing home residents leads to greater morbidity and mortality than sheltering in place (Willoughby et al., 2017; Harris and Wellenius, 2018). Nursing homes often lack resources and infrastructure to evacuate residents to a facility with a similar level of care, including the transfer of patient information, medicine and medical records, and other medical equipment (CDC, 2004).[18]

Adults in Idaho aged 60+ increased by 21% between 2017 and 2020 (Idaho Commission on Aging, 2020). Adults aged 60+ living in rural areas increased by 17,250 (16%).

3.2 Pregnancy and Child Development[19]

Climate change impacts infant and child health and development in myriad ways. This includes physical health, mental health, and cognitive function from in utero to adolescence.

Lungs require about eighteen years to fully form; development continues through adolescence. Decreased air quality due to warming temperatures leads to an increase in ground-level ozone formation. In addition, the amount of pollution, dust, and smoke in the air increases with greater wildfire intensity and frequency. For children, these changes may increase the number and severity of asthma episodes and exacerbated allergies (EPA, 2016b). If the long-term consequences of smoke inhalation mirror those of air pollution, then lung function could be reduced into adulthood (Capradio, 2020; USC, n.d.). Exposure to wildfire smoke may impair children’s immune system function, certainly in the short-term (Prunicki et al., 2019).

Infants and toddlers breathe, eat, and drink more relative to their body size compared to adults. Moreover, children’s immune and organ systems are immature; exposures can cause permanent disabilities. Sensitivity to pollutants or allergens may lead to increased asthma episodes (EPA, 2016b). Heat-related illness, such as heat stroke and heat morbidity, also pose threats to infants and toddlers, as they are less able to regulate body temperature (EPA, 2016b). Children and youth exerting themselves in outdoor strenuous activity, especially those requiring heavy clothing or gear, such as football and rugby, are at increased risk for exertional heat illness (e.g., Kerr et al., 2019).

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[18] This study is from 2004; however, it is comprehensive in scope.

[19] Section contribution by Katherine Himes, Ph.D., director, University of Idaho James A. and Louise McClure Center for Public Policy Research.

Children may experience difficulty controlling emotions and decreased ability to focus in school, as well as depression, anxiety, and post-traumatic stress, as a result of extreme weather events that cause injury, death, or displacement (EPA, 2016b; Helldén et al., 2021). Though children may be resilient with respect to such events, mental health impacts can last into adulthood, particularly when untreated (EPA, 2016b; Helldén et al., 2021).

During pregnancy, exposure to wildfire smoke (Abdo et al., 2019), extreme temperatures (EPA, 2016b; Zhang et al., 2017; Helldén et al., 2021), and flood-related contaminants (EPA, 2016b) are associated with an increase in the risk of preterm birth and lower birth weight, which have implications for both neonatal health and overall child development. Heat waves, which are projected to increase in Idaho, increase the chances of early labor, stillbirth, and/or having a baby with low birthweight (Cherisich et al., 2020; Sommer, 2021). One study found that for every extra 10°F increase in temperature, risk of preterm birth goes up by 8% (Basu et al., 2010).

Air pollution broadly impacts brain development; exposure to $PM_{2.5}$ and ultrafine particles are associated with overall inflammation, as well as biochemical features of autism, attention-deficit disorder, schizophrenia, and impaired learning and memory (Peeples, 2020). Exposure to wildfire smoke and increased levels of pollution are associated with both lower school attendance and lower test scores (Lavy and Roth, 2014; Park et al., 2020). In the long-term, this may lead to lifetime lower earning capacity and a less productive workforce (Lavy and Roth, 2014).

More frequent high temperatures can decrease student learning over time (Park et al., 2020). A nationwide study of 10 million U.S. children found that the average temperature inside a school building impacts test performance, taking into account student background, grade, and prior academic performance. For the average student, a sustained increase in of 3.6°F in school building temperature lowers achievement gains by approximately 7% of an average year's learning (Park et al., 2020). In addition, every school day above 90°F lowered students' scores further. Students' academic achievement can be impacted 2-4 years later through cumulative effects, such as physiological impacts of heat on decision-making and focusing for both students and teachers, as well as early dismissals (decreased amount of time in the classroom) during periods with particularly high temperatures. Park et al. (2020) also presented evidence on school air conditioning mitigation of heat-related learning impacts, consistent with a growing body of literature.

3.3 Unhoused Populations

Housing instability impacts physical and mental health (Ramin and Svoboda, 2009). These impacts and health costs can increase as unhoused individuals are exposed to heat, smoke, and poor air quality (Bezgrebelna et al., 2021). Common conditions among people without housing are heat stroke, dehydration, and respiratory illness (Every et al., 2019). Malnourishment among people without housing further decreases the capacity to tolerate temperature extremes and the risk of death from heat is increased for those with psychiatric disorders, substance use disorders, and cognitive impairment (Ramin and Svoboda, 2009).

As of January 2020, Idaho had an estimated 2,315 people without housing. Of that total, 276 were family households, 178 were veterans, 90 were unaccompanied young adults (aged 18-24), and 364 were individuals experiencing chronic lack of housing (U.S. Interagency Council on Homelessness, 2020).

3.4 People with Disabilities and Chronic Conditions

People with disabilities are vulnerable to increasing exposures brought on by heat, poor air and water quality, and climate change hazards, particularly with respect to evacuation and displacement (Stough and Kang, 2015). Factors that contribute to this vulnerability may include poverty, fixed and limited incomes, health care access, and inadequate housing, amplifying risk and exposure to climate change hazards (Stough and Kang, 2015; Okoro et al., 2018). Mental distress[20] is reported 4.6 times as often as adults without disabilities (32.9% vs. 7.2%, respectively). Adults with disabilities living below the poverty line report mental distress 70% more often than those in higher income households (Cree et al., 2020). As noted in an earlier section, mental distress may increase with climate change.

Emergencies and disasters like wildfires and flooding can occur quickly and without time to assemble medical resources. In the face of an emergency evacuation, people with disabilities risk separation from their caregivers and assistive devices (Internal Displacement Monitoring Centre (IDMC), 2021). Temporary shelters and facilities may be inaccessible and unsafe for people who are blind or have other physical or cognitive disabilities (United Nations Office for Disaster Risk Reduction (UNDRR), 2015). Emergencies and disruptions can cause ongoing disruptions to health care, medication, assistive devices, proper nutrition, rehabilitation, and mental health services and these disruptions pose a particular hardship to people with disabilities of all ages (IDMC, 2021). Considerations include knowledge of evacuation processes, accessibility of evacuation shelters, potential delays in evaluation, and physical obstacles due to functional impairments (CDC, 2020b).

In 2019, 26.8% of Idaho adults 18 years of age or older and 42.9% of Idaho adults 65 years and older reported having a disability (Disability and Health Data System (DHDS), 2021). The top four functional disability types impacting Idahoans are cognitive disability (11.3%), mobility disability (10.7%), independent living disability (7.3%), and hearing disability (7.0%) (DHDS, 2021). The number of people with disabilities in Idaho is rising due to the increase of chronic health conditions and an aging population (CDC, 2021b). Adults with disabilities are more likely to have climate change sensitive conditions than adults without disabilities; for example, in Idaho, asthma (16.5% vs. 6.3%), COPD (10.9% vs 2.9%), diabetes (17.4% vs. 5.8%), and stroke (6.7 % vs 1.4%) (DHDS, 2021). In 2017, disability costs as part of health care expenditures in Idaho were $3.5 billion. This represents 33% of all health care expenditures (CDC, 2021b).

Individuals with chronic conditions, such as cardiovascular and respiratory conditions, renal disease, and diabetes; those taking medications that increase heat-related illness susceptibility; and those with disabilities, are more vulnerable to extreme heat than the population as a whole (Sarofim et al., 2016; Jonhson et al., 2019). Diabetes affects the ability to regulate body temperature and many medications for diabetes can lead to dehydration and lose their effectiveness in extreme heat (Kenny et al., 2016). Heat

[20] Frequent mental distress is defined as 14 or more mentally unhealthy days in the past 30 days. Frequent mental distress is associated with poor health behaviors, increased use of health services, mental disorders, chronic disease, and limitations in daily life (Cree et al., 2020).

exposure also contributes to causes of death attributed to particular chronic conditions, alcohol poisoning, and drug overdoses (Abbinett et al., 2020). Of these deaths, 90% (9,757) occurred during May-September, 70% occurred in males, and the largest percentage of heat-related deaths (39%) occurred among people aged 65 years of age and older.

Rural Idaho counties have higher rates of disability and chronic diseases than urban counties (University of Montana Rural Institute, n.d.) (Figure 9).

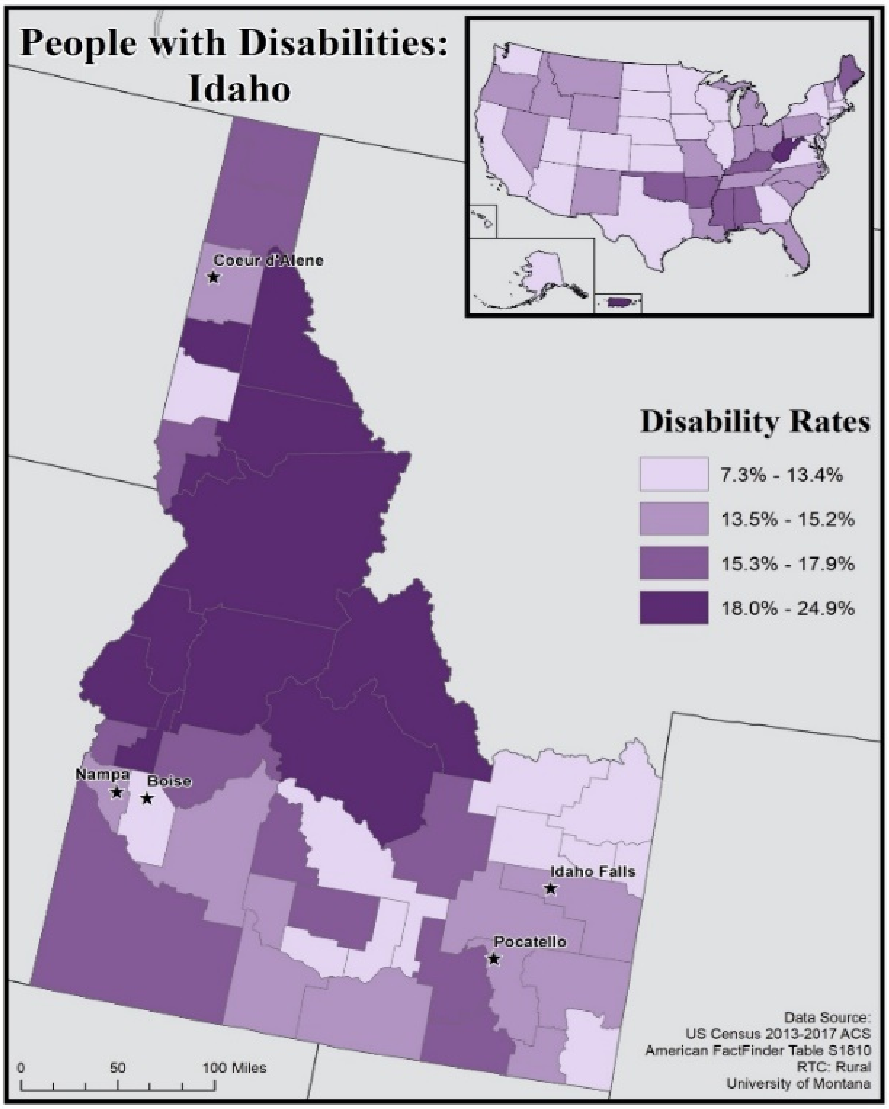


Figure 9. People with disabilities in Idaho, disability rate by county (University of Montana Rural Institute, n.d).

3.5 Indigenous People and Tribes

The Third and Fourth National Climate Assessments (NCAs) each incorporated a chapter focused on climate impacts to Indigenous people.[21] While Indigenous people may be affected by climate change in similar ways to others in the U.S., they also may be disproportionately and uniquely impacted (Jantarasami, 2018).

The impacts of climate change-related risks on Indigenous populations faced are multifaceted, complex, and varied over time. For example, wildfires pose immediate risk of death, injury, and economic loss, as well as physical and mental health risks. Wildfires in heavily timbered areas may require evacuation, introducing additional risks inherent with displacement—isolation, distress, lack of access to health care and life-saving medical devices and medication, inability to obtain food and adhere to dietary practices, and others. Temperature extremes exacerbate health impacts of wildfires, particularly when power is unavailable for cooling, safe food and medicine storage, and food preparation. The timing of wildfires can disrupt the normal cycles of hunting, fishing, food and medicinal plant gathering, and cultural and spiritual practices, diminishing health and adding further distress (Lynn et al., 2013). Wildfires have long-lasting impacts on habitat essential for wild game, fish, and plant life; water quality and quantity; recreation; and cultural and spiritual practices.

3.6 Outdoor Workers

Occupational heat stress and poor air quality from wildfires impact worker health and productivity; these impacts are projected to increase with warming working conditions (Balbus et al., 2016; Casico, 2018; Gao et al., 2018). Those who work in construction, agriculture and forestry, landscaping and yard maintenance, electrical power transmission and control, emergency response, armed services, and others who spend a significant portion of their workday outdoors and are exposed to high heat and/or humidity are at risk for heat-related illness and death (Balbus et al., 2016). Working long shifts during the hottest part of the year, in direct sunlight,[22] and during the hottest part of the day increase the possibility of injury and death (OSHA, 2014). Impacts of heat-related illness for outdoor workers increases with high heat early in the warm season, inadequate acclimatization to heat, high workload severity and duration, and heavy or non-breathable personal protective equipment (PPE) and protective clothing (OSHA, 2014).

Agricultural workers are extremely vulnerable to heat-related illness, chronic conditions, and death (Moyce et al., 2017). A CDC study from 2008 analyzed 423 heat-related deaths among workers exposed to heat between 1992 and 2006. Crop workers faced an annual rate of death nearly 20 times that of all workers (0.39 deaths per 100,000 crop workers compared to 0.02 deaths per 100,00 workers in all occupations). Nearly all of the deceased crop workers were male; 78% were aged 20-54 years and nearly 60% of the deaths occurred in July (CDC, 2008). Estimates range from 33 to 79% of crop workers experiencing heat-related illness (Spector et al., 2015).

At greatest risk for heat-related illness in Idaho are those working long hours during the hottest times of the year and without shade, rest, and specific water requirements for extreme temperature (Curl et al.,

[21] For more information, see https://nca2014.globalchange.gov/report/sectors/indigenous-peoples and https://nca2018.globalchange.gov/chapter/15/ Indigenous, Native, and tribal are used in both reports.
[22] This can add 15 degrees to the temperature.

2021). Although there are no specific OSHA standards that protect workers from heat-related illness (OSHA, 1970), in September 2021, OSHA announced it will begin the process of developing workplace heat standards for both indoor and outdoor job sites. OSHA also has formed a National Advisory Committee on Occupational Safety and Health and Heat Injury. NIOSH has recommended standards as well (CDC, 2016).

A meta-analysis including 447 million workers indicated that individuals working under heat stress were over four times more likely to experience occupational heat strain, with 35% of the workers experiencing heat stress and 30% reporting lower productivity (Flouris et al., 2018). Studies suggest an average 2.6% productivity decline for every 1.8°F increase beyond 75.2°F WBGT[23] (Flouris et al., 2018). A recent study by Atlantic Council Adrienne Arsht-Rockefeller Foundation Resilience Center (2021) found that the U.S. is on track to lose an average of $100 billion annually from heat-induced lost labor productivity. This number is expected to reach $200 billion by 2030 (Atlantic Council Adrienne Arsht-Rockefeller Foundation Resilience Center, 2021).

Mental Health

Idaho-specific research on mental health-related impacts and climate change anxiety has not been conducted. Idahoans experience mental health concerns, have limited access to mental health providers, and can lack insurance to cover mental health treatment; these factors can contribute to Idahoans' risk for climate-related mental health impacts. Mental Health America ranks U.S. states for mental health illness prevalence and access to care by combining 15 adult and youth mental health measures on an annual basis. Idaho adult mental health ranked 47th, youth mental health ranked 48th, and access to mental health care ranked 35th (Mental Health America, 2021). From September 29 to October 11, 2021, the U.S. Census Bureau Household Pulse Survey data indicated that 29.1% of Idaho adults reported symptoms of anxiety disorder, 21.6% depressive disorder, and 33% symptoms of anxiety and/or depressive disorder (all slightly lower than national rates).[24]

High ambient temperatures have been associated with increased violence and mental health risks, the strongest association being for suicide risk (Thompson et al., 2018). The rate of suicide in Idaho is consistently higher than the U.S. average; in 2018, Idaho had the 5th highest rate of suicide in the nation, at 1.5 times the national rate (23.8 per 100,000 vs. 14.8 per 100,000), with the highest rates among rural areas of the state (Spearman et al., 2019). Several studies link drought, extreme heat, poor air quality, and other exposures to suicide, particularly among people whose way of life is tied to natural resources (Dumont et al., 2020). Climate-related exposures and their related sequelae, such as disease, displacement, loss, etc., may further impact the mental health of Idahoans.

4. Opportunities

Climate Change and Health Planning in Idaho

Risks of temperature extremes, wildfires, flooding, drought, and more are identified in public health emergency plans in Idaho; these plans to date do not include climate change projections or specific

[23] The WetBulb Globe Temperature (WBGT) is a measure of the heat stress in direct sunlight, which takes into account temperature, humidity, wind speed, sun angle, and cloud cover (solar radiation).
[24] For more information, see https://www.cdc.gov/nchs/covid19/pulse/mental-health.htm

mention of impacts of climate change on health. IDHW does address environmental exposures to health, but does not identify climate change as associated with extreme weather events and other environmental changes that impact human health. Idaho cities, counties, and tribal communities are implementing climate action planning. Some plans identify climate- and health-related risks and include health data and related indicators and interventions.

There are opportunities in Idaho to prepare for health impacts associated with climate change:

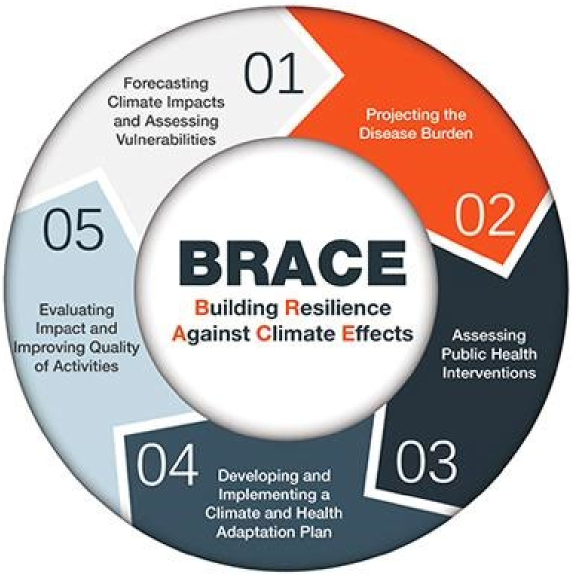
- Increased awareness of climate change-related health risks, including mental health.
- Resources that describe risks of extreme heat and poor indoor and outdoor air quality to workers, childcare facilities and schools, and adults in long-term care could be provided.
- Warning systems and health communication for extreme weather events that meet literacy and language needs could be crated.
- Access to safe clean air, cooling, and heating centers during an extreme weather event can relieve health impacts.
- The local food system could serve as a way to decrease impacts of climate-related food supply disruptions.

Climate Change Impacts on the Health of Vulnerable Populations

The CDC recommends a step-by-step process to develop strategies and programs to assist communities in preparing for impacts of climate change on health. The Building Resilience Against Climate Effects (BRACE) framework, developed by the CDC, helps health officials, health systems, tribes, and others anticipate, prepare for, and respond to climate change-related health exposures (CDC, 2019a). BRACE is one example of such a framework.

The five sequential steps of the BRACE model (CDC, 2019a):

1. **Anticipate climate impacts and assess vulnerabilities:** Identify the scope of climate impacts, potential health outcomes, and populations and locations vulnerable to climate change.
2. **Project the disease burden:** Estimate or quantify the additional burden of health outcomes associated with climate change.
3. **Assess public health interventions:** Identify the most suitable evidence-based health interventions for the identified health impacts of the greatest concern.
4. **Develop and implement a climate and health adaptation plan**: Develop a written adaptation plan that is regularly updated. Disseminate and oversee implementation of the plan.
5. **Evaluate impacts and improve quality of activities:** Create an evaluation plan to evaluate the merit, worth, and effectiveness of actions taken and desired outcomes.



A few opportunities for Idahoans to prepare for climate impacts to health, connected to the BRACE model, include:[25]

- Consider climate change vulnerability as part of hospital, public health district, state, tribal, local, and other Community Health Assessments.
- Incorporate climate change impacts on health into existing emergency preparedness planning.
- Support climate and health modeling efforts to identify and project climate-related health challenges and integrate this information in public health, health system, regional, tribal, and local planning.
- Consider creation of systems and processes to obtain health and economic data from hospital admissions, emergency room visits, emergency transport, clinic visits, and insurance companies, both private and public, to allow for robust analysis of impacts of climate exposures to health and the economy.

Climate Change and Practitioner Training

Health professionals are recognizing the importance of including the health impacts of climate change in medical education and training to prepare future practitioners (AAMC, 2021). Incorporating impacts of climate change on health into curricula can improve health outcomes, decrease health costs, and decrease mortality, as practitioners recognize and address these impacts (Maxwell and Blashki, 2016; Wellbery et al. 2018; Howard, 2021). Approximately 20% of medical schools include information about impacts of climate change on health in their curriculum (Earls, 2019). Understanding how climate change acts as a threat multiplier, impacting existing conditions, is an emerging area of training (Earls, 2019).

5. Summary

Climate change poses risks to health and will increase direct and indirect health-related costs for local, state, tribal, and federal economies (Hsiang et al., 2017; Jantarasami, 2018; Limaye et al., 2019; Limaye

[25] For additional information and resources, see the Tools and Resources page on the assessment website.

et al., 2020; Patz et al., 2020). Impacts observed in earlier reports (e.g., USGCRP, 2016) will increase with current greenhouse gas emissions (Romanello, 2021)

The most widespread direct and indirect impacts of climate change on Idahoans' health are from poor air quality due to wildfire smoke and high temperatures. Many indirect impacts exist that affect wellbeing, productivity, life expectancy, and economic health. Other Idaho climate-related health risks include vector-borne disease, diminished water quality and quantity, harmful algal blooms, and challenges related to food safety and food security, mental health, and others. Idahoans will not experience health-related economic impacts of climate change uniformly. Idaho's geographical diversity and differences in population density, infrastructure, income, access to health and human services, age, health status, and more all will influence how human health will be affected. Climate change-related health impacts disproportionally affect the elderly, the young, pregnant women, individuals with chronic diseases and disabilities, and people who lack health care access and economic resources. Outdoor workers, such as those employed in agriculture, construction, and public safety, face greater impacts of smoke and temperature extremes. Tribal populations face particular climate-related health vulnerabilities due to loss of natural resources, physical displacement, and First Food and economic losses, all of which impact essential spiritual and cultural practices.

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