

BUILDING RESILIENCE AGAINST CLIMATE EFFECTS

ARIZONA  
**EXTREME WEATHER,  
CLIMATE AND HEALTH**

PROFILE REPORT  
MARCH 2015



PREPARED BY:



# EXECUTIVE SUMMARY



## EXECUTIVE SUMMARY

### Rationale and objectives

Observed and projected changes to the climate (e.g. more/less precipitation and higher temperatures) can pose significant health risks to the residents of Arizona. As in other locations in the Southwest, across the United States, and around the world, these changes are likely to coincide with an increased frequency of drought, flooding, severe heat events, and wildfires; and disruption of civil infrastructure, including transportation, energy, and water systems. These impacts can lead directly to illness and death and are likely to worsen existing health conditions, such as cardiovascular diseases, asthma, and other respiratory illnesses.

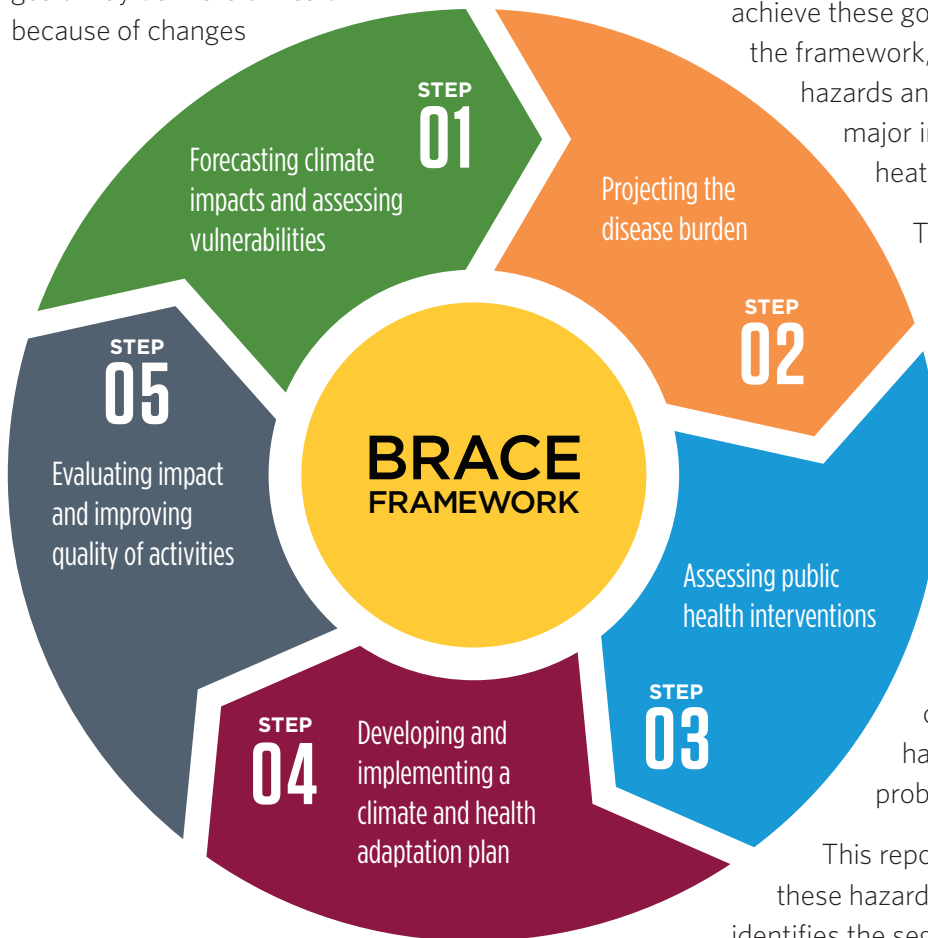
A number of other factors are expected to compound these health issues. Achieving air quality goals may be more difficult because of changes

in the emission rates of ozone precursors including nitrogen oxides (NO<sub>x</sub>), carbon monoxide (CO), and volatile organic compounds (VOCs), along with changes in meteorological conditions that facilitate high pollutant concentrations. Additionally, the timing and potency of aeroallergens may be hastened and increased. Finally, vector-borne illnesses carried by insects (i.e., mosquitos, mites, and ticks) are likely to become increasingly widespread.

The U.S. Centers for Disease Control and Prevention (CDC) have developed the *Building Resilience Against Climate Effects* (BRACE) framework (Figure A) to provide local health officials with a mechanism for addressing climate-related public health effects and to support the creation of regional public health adaptation and mitigation efforts. The framework uses the principles of adaptive management to achieve these goals. This report addresses Step 1 of the framework, focusing on two climate-related hazards and associated health impacts of major importance to Arizona—extreme heat events and air pollution.

The frequency and intensity of extreme heat events already are increasing in the state and this trend is expected to continue. Likewise, under some future climate scenarios, ozone formation and accumulation are expected to increase (Weaver et al. 2009; Kim et al. 2015). Furthermore, historical monitoring of air pollution, especially ozone and coarse particulate matter (PM<sub>10</sub>), has identified these pollutants as a problem in the state.

This report describes the link between these hazards and human health outcomes, and identifies the segments of the population that would be at-risk or vulnerable to their effects.



**Figure A** The five-step BRACE framework. Source: Adapted from Marinucci et al. (2014).

The work involved extracting downscaled climate projections for Arizona and identifying populations vulnerable to extreme heat and poor air quality. Further work will include projecting future public health burdens, identifying mitigating measures, evaluating their cost-effectiveness, and developing an adaptation plan. Flood- and drought-related hazards will also be analyzed. Throughout these activities, Arizona Department of Health Services (ADHS) and the project team will evaluate the framework's effectiveness and revise their efforts, as needed.

### Projections summary

Regional and national climate assessments typically provide estimates of future changes at national and regional scales. These are generally too coarse to use for county and sub-county public health impacts. Applying a “downscaled,” or layered, projection model is one way to transfer coarse projections to finer geographic scales to aid in adaptation planning and decision making. However, it typically requires a number of different models and “runs,” or computational cycles, to obtain the most accurate predictions for multiple impacts. For instance, there were at least 37 downscaled models and more than 200 model runs used in the *Coupled Model Intercomparison Project Phase 5 (CMIP5)* of the World Climate Research Program in 2013. Multiple models and runs add significant time and costs to assessments.

As a starting point for the BRACE Step 1 analysis, the interdisciplinary team employed a single model run, the Hadley Centre Global Environmental Model version 2 Earth System configuration (HadGEM2-ES) published by the Met Office Hadley Centre in the United Kingdom. The team chose HadGEM2-ES because its historical simulations have shown low bias (i.e., a low error rate between predictions and actual changes) across North America compared with other models. Since using a single model output does not represent the whole range of future projections, future estimations for this project will incorporate additional downscaled models.

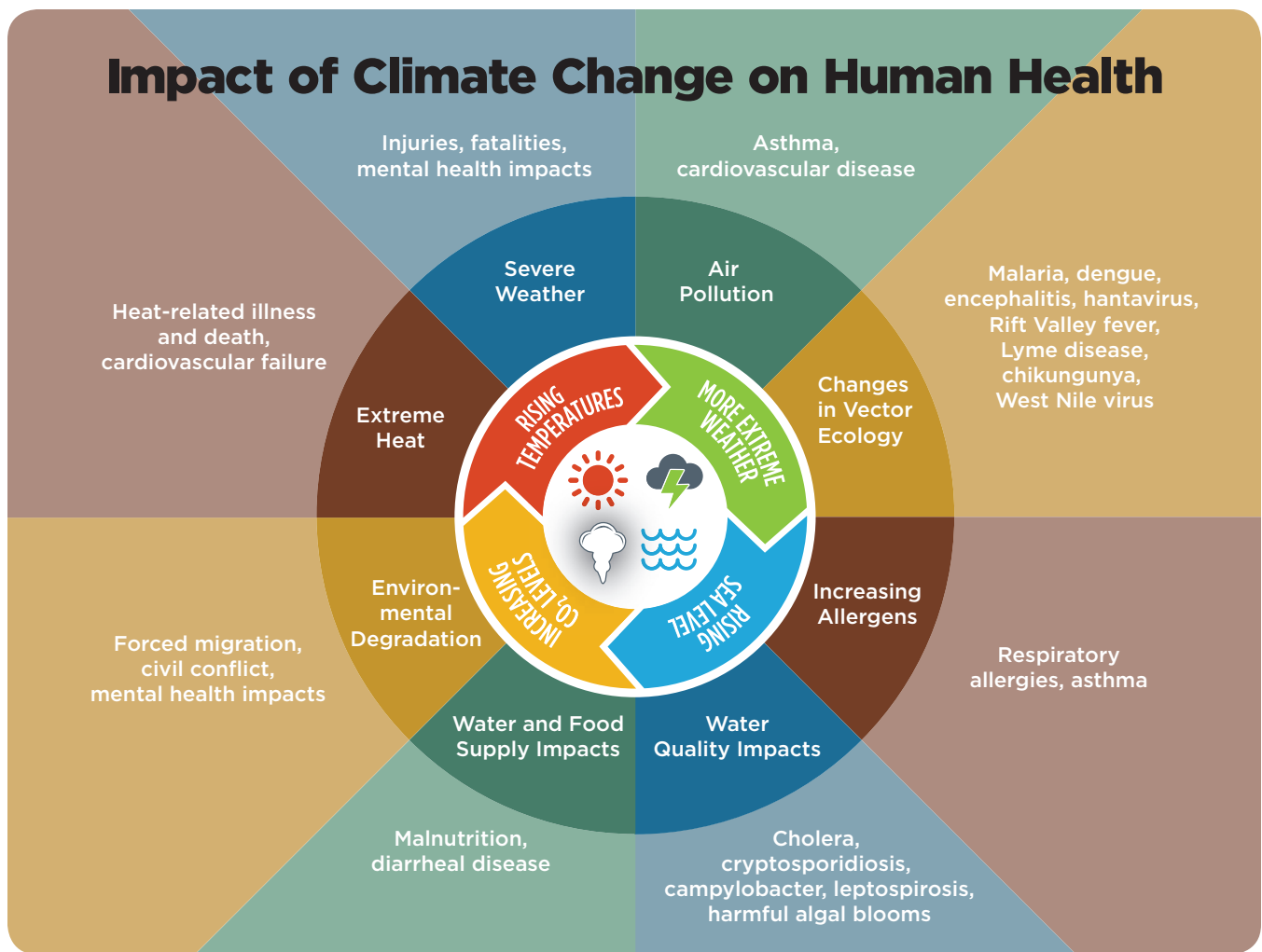


Consistent with the most recent climate science, as embodied in the Intergovernmental Panel on Climate Change's *Fifth Assessment Report*, the project team evaluated future temperature scenarios in Arizona according to the four representative concentration pathways (RCPs). These RCPs included the highest and lowest GHG concentration scenarios between 2000 and 2100 – both with and without climate mitigation scenarios. Thus, RCPs provide a framework that will enable the scientific modeling community to undertake long- and near-term modeling experiments.

Overall, downscaled projections showed that the largest temperature changes are likely to occur in the state's more rural areas. In the medium and high RCP scenarios, the largest temperature increases were observed in northeastern and northern Arizona, including Mohave, Coconino, Navajo, and Apache Counties. The highest projected temperature increase in 2030 was seen in Mohave County under the RCP 2.6 scenario, with a 4.56°F increase from the 2010 baseline. In the year 2060, Navajo and Apache Counties also might experience temperature increases of as much as 3.64°F - 3.75°F.

### Climate-sensitive health issues

A wide range of human health issues have been shown to be sensitive to environmental triggers



**Figure B** Conceptual Pathways of Climate and Health. Source: CDC Climate Effects on Health - [www.cdc.gov/climateandhealth/effects/](http://www.cdc.gov/climateandhealth/effects/)

and conditions (Figure B). The prevalence and distribution of these issues are expected to shift with a changing climate and subsequent impacts on aquatic, terrestrial, and atmospheric environments and ecosystems. In fact, national and international research bodies have established numerous conceptual pathways linking climate to human health. These pathways range from those that occur over short time scales (i.e., minutes, days), with direct links between climatic conditions or extreme weather events and health problems to those that occur over decadal (or longer) time scales and involve many intermediary environmental and/or human processes or behaviors.

Short-term, direct pathways are relatively straightforward, as the climate- and weather-related

impacts themselves are the direct cause of illness and death. An example of a direct pathway would be a person drowning during a flash flood. Health issues directly related to extreme heat exposure are of particular concern in Arizona because much of the state experiences dangerously hot weather during the warm season. For example, the increased frequency and severity of extreme high-temperature events is very likely to increase the rate and occurrence of heat-related illnesses, including hyperthermia or heat stroke, and heat-related deaths.

Indirect, longer-term pathways connecting climatic and health issues are more difficult to measure and observe, but likely affect a much larger portion of the population due to the variety of mechanisms and extended time periods involved. In Arizona,

the increased frequency and severity of extreme temperatures is expected to lead to human health impacts beyond heat stroke and heat-related deaths in a variety of ways. For instance, increases in the number and intensity of higher, less tolerable outdoor temperatures are likely to discourage outdoor exercise and recreation, as well as the use of non-motorized transportation. This, in turn, may increase the likelihood of chronic health conditions associated with sedentary lifestyles.

Increasing incidence of extreme heat can also affect air quality as concentrations of some pollutants, including ozone, are partially dependent on temperature. Poor air quality affects a large portion of Arizona's population living in regions that find it difficult to meet federal air quality standards for particulate matter (PM) and ozone, or that face challenges in maintaining compliance. Epidemiological research has found associations between increasing PM concentrations and total death rates; as well as hospital admissions for asthma, chronic obstructive pulmonary disease (COPD), cardiovascular disease, decreased lung function, and other respiratory symptoms. In children, exposure to PM has been found to hamper lung development.

Short-term ozone exposure can also result in respiratory health issues, including decreased lung function, cough, chest pain, shortness of breath, inflammation, and emergency room visits for respiratory issues. There is suggestive evidence that ozone exposure is associated with cardiovascular disease and total death rates. In addition, criteria air pollutants—those regulated by the U.S. Environmental Protection Agency—and the production and distribution of aeroallergens, including pollens and molds, are also likely to shift with increasing temperatures. Many individuals are sensitive to and suffer allergic reactions from airborne pollens (e.g., tree, weed, and grass) and mold. Thus, common allergic reactions and diseases, including rhinitis, asthma, and eczema, are expected to increase.



Due to the significance of extreme heat, air quality issues, and the host of health impacts that stem from these environmental conditions, this report focuses on heat and air pollution. Future BRACE reports will address two additional environmental drivers that are likely to change in ways that will affect public health—flooding and drought. Additionally, infectious diseases, which are likely to shift with changing environmental conditions, will be discussed in future reports.

### **Vulnerable demographic groups and geographic areas**

Public health vulnerability describes the extent to which a given population is susceptible to death and illness. Scholars have identified three major components that affect a population's or system's degree of vulnerability—exposure, sensitivity, and adaptive capacity. Exposure includes proximity to or direct contact with environmental hazards, such as heat waves, air pollution, extreme weather events, or disease vectors. Sensitivity refers to population characteristics that influence the degree of susceptibility to the hazard—including race, ethnicity, poverty, access to health care, and access to transportation. Finally, adaptive capacity refers to the ability to modify behavior to prepare for the anticipated changes. Using these parameters, the team identified vulnerable demographic groups and geographic areas in Arizona by referencing academic literature and constructing several social vulnerability indicators using census data.

## RATIONALE FOR POTENTIAL COLLABORATIONS IDENTIFIED

Successfully completing subsequent steps in the BRACE framework will require incorporating additional collaborators. Future partnerships will build on existing relationships established by ADHS and ASU. Stakeholder engagement is critical throughout all steps of the BRACE framework.

### STEP

# 01 >>

Partnerships with agencies and organizations that have access to local climate data and projections, as well as those that can review and summarize literature on related health impacts, have helped inform the climate projections and vulnerability assessments.

### STEP

# 02 >>

Engaging organizations that can employ qualitative and quantitative approaches to assess the climate and health data can help with projecting the disease burden.

### STEP

# 03 >>

Collaborators will be essential in identifying the range of health interventions available for each health outcome; as well as assessing the capacity to deliver each intervention, and prioritizing health interventions deemed most suitable for Arizona.

### STEP

# 04 >>

Collaborators will also be essential to support the dissemination of the Arizona Strategic Climate and Health Adaptation Plan, because those agencies and organizations may play a part in implementing the interventions.

### STEP

# 05 >>

Additionally, stakeholder engagement will be crucial for evaluating effective implementation of interventions, assessing whether climate and health are considered in broader public health planning, and establishing whether actions taken improved health outcomes.

**Vulnerability to extreme heat events** - Human vulnerability to extreme or excessive heat events (EHEs) involves more than physical exposure. It also involves individual and population sensitivity to EHEs and adaptive capacity. Sensitivity depends on the underlying characteristics of a population, such as age and ethnicity, while adaptive capacity reflects the capability of a system, population, or individual to cope with changes. The interdisciplinary team has identified the characteristics that make populations vulnerable to heat, as well as the locations (i.e., the places in which vulnerable populations congregate) where interventions are most needed. Reviews of this work show that low-income groups, African

Americans, Latino Americans, Hispanic Americans, Native Americans, people with weak social ties, infants, the elderly, and those without access to air conditioning, are among the groups that usually suffer the effects of heat stress at rates that exceed those found in the general population.

**Vulnerability to air pollution** - Vulnerability to air pollution-related illnesses and death is known to be worse among the very young and very old, those in poverty, those without a high school diploma, workers with occupational exposures to air pollution, and those living near heavily traveled roadways.

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