Gap Analysis of Climate and Health Research in Arizona

A Report by the Research Action Team of Bridging Climate Change and Public Health
in Cooperation with the Maricopa County Department of Public Health

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Executive Summary

The Research Action Team of Bridging Climate Change and Public Health investigated research related to climate-sensitive public health hazards specific to Maricopa County, Arizona and the surrounding Southwest region. Examples of climate-sensitive public health hazards that are important for our area include extreme heat, poor air quality, vector-borne diseases, flooding, and dust storms. A review of the academic research literature revealed 102 relevant publications. Data were extracted from each study to identify gaps in research for potential future studies related to climate-sensitive public health hazards. The data extracted included study design, duration of the study, climate change outcomes, health outcomes, and Arizona county (county vs. All Arizona vs. Southwest). Studies were dated from 1950-2019, with the majority of research within Arizona happening in Maricopa County, Arizona. Heat and air quality are the climate change impacts that have dominated the literature for Arizona thus far. An intersection analysis of climate change impacts and health outcomes revealed these nine important gaps that represent opportunities for future research:

1) (built environment) AND (alternative ways of transportation)
2) (adaptation, mitigation, and interventions) AND (asthma and other respiratory illnesses)
3) (adaptation, mitigation, and interventions) AND (cardiovascular health)
4) (adaptation, mitigation, and interventions) AND (malnutrition)
5) (adaptation, mitigation, and interventions) AND (alternative ways of transportation)
6) (impacts of food supply) AND (malnutrition)
7) (occupational health) AND (asthma and other respiratory illnesses)
8) (occupational health) AND (Valley Fever)
9) (occupational health) AND (cardiovascular health)

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Background

In 2017, the Maricopa County Department of Public Health (MCDPH) convened a smaller group of key Bridging Climate Change and Public Health (BCCPH) participants to begin a strategic planning process on climate and health for Maricopa County. The meeting participants formed the *Bridging Climate Change and Public Health Strategic Planning Workgroup*, which developed a strategic plan with five priority actions for addressing environmental concerns affecting the health and well-being of the community. A completed "Climate and Health Strategic Plan for Maricopa County" workgroup report was published by MCDPH in 2018. Further, each strategic direction is represented by an action team. Action Teams comprise a lead, a co-lead, and members who discuss priority actions, create implementation steps, goals, accomplishments, and establish project deadlines. For the sake of simplicity, the action teams have added a nickname such as Environmental Action, Research, Communication, Education, and Champions.

This analysis has been completed by the Research Action Team which is dedicated to increasing collaborative efforts in the climate change and health research area with a key deliverable of collaborating on a gap analysis of research on climate and health in Arizona. The objective of this assessment is to collate and synthesize peer-reviewed literature and reports on climate change and health in Arizona and to identify gaps as opportunities for future research.

Bridging Climate Change and Public Health

The five strategic directions of BCCPH:

- Fostering Environmental Action for a Healthier Community - ENVIRONMENTAL ACTION
- Coordinating Research and Collaborative Efforts to Catalyze Change - RESEARCH
- Developing a Strategic and Targeted Communication Plan - COMMUNICATION
- Promoting Community Awareness and Public Education about Climate and Health - EDUCATION
- Celebrating Success and Champions - CHAMPIONS

For more information, or to volunteer time or resources to an Action Team, visit https://www.maricopa.gov/4640/Climate-Change-and-Public-Health or email ClimateAndHealth@mail.maricopa.gov.

Methods

Selection of Climate Change and Health Outcomes

This study comprises an analysis of specific climate change impacts and health outcomes that were chosen based on expert opinion from stakeholders in the BCCPH Research Action Team. The 10 selected climate change impacts and 10 health outcomes were based on previously identified associations as well as reports from the Arizona Department of Health Services.[1,2]

Selection of Papers

A scoping review was initiated in PubMed, Web of Science, and EMBASE to find literature on climate change and health in Arizona. The following search strategy was used to identify articles: (((‘climate’ OR ‘climate change’ OR ‘weather’)) AND (‘health’ OR ‘human health’)) AND (‘Arizona’ OR ‘Southwest’) with restrictions on the English language. Personal reference libraries of authors (EA, HEB, DH) and reference lists of some of the articles found

Table 1. Inclusion and Exclusion Criteria

Criterion	Inclusion	Exclusion
Participants	Any human population	The non-human population studied, or general impacts on the environment
Time period	Papers published before April 17, 2019	N/A
Language	Papers available in English	Non-English studies
Study Designs	All epidemiologic study designs and disease burden models/estimates	Frameworks and commentary on collaborative efforts.
Format	Peer-reviewed research articles, book chapters, and reports	Conference abstracts, videos, news articles
Outcomes	Climate Change Impacts or Mitigating Activities: extreme heat, poor air quality, impacts on vectors (e.g. mosquitoes, ticks), species extinction, extreme weather events, water management, built environment, adaptation mitigation or interventions related to climate change, impacts to food supply and nutrition, impacts on occupational health, other (Free text) Health Outcomes or Health Co-Benefits: asthma or respiratory conditions, heat-related illness and death, vector-borne diseases, infectious diseases, mortality, morbidity, cardiovascular health, malnutrition, alternative forms of transportation, mitigation effects, other (free text)	Any non-climate change or non-human health-related outcomes, or studies who did not measure impacts on human health

("snowballing") were also reviewed for additional articles. The preliminary selection was completed on April 17, 2019, including all articles published before that date.

Articles were screened for inclusion by three reviewers independently using title and abstract. Following the screening, the full-text review for inclusion was completed independently. The primary criteria for inclusion were that it must: study human health impacts of climate change or extreme weather, and include Arizona in the analysis (Table 1). A shared Google Sheets document was developed to track the progress of selection, screening, and data extraction.

Data Extraction

Data from each paper was extracted independently. Conflicts between the reviewers were resolved via consensus or with a third reviewer extracting the data if needed. If full-text articles were not available (e.g. payment required), data were extracted based on the abstract (n=3). If data extraction could not be completed from the abstract, the first author was contacted for relevant data, although no authors responded to these requests (n=3). Data extracted from each study included: author, publication year, study design, duration of the study, climate change outcomes, health outcomes, and Arizona county (county vs. All Arizona vs. Southwest).

Description of Observational Study Designs (adapted from the CDC)

In an **observational study**, the epidemiologist or scientist simply observes the exposure and disease status of each study participant.

In a **disease burden** or **surveillance estimates** study, the scientist utilizes models or large datasets to understand the distribution of disease in a large population. Often these models utilize other smaller studies to build the model and apply these to an overall population.

In a **cohort** study the scientist records whether participants were exposed or not and then tracks the participants over time, which can vary considerably. Sometimes these studies are done prospective (future) or retrospective (look into the past from a present disease state).

In an **ecological** study, the scientist records participant data at the population or group level, rather than on an individual level. These are often used when an event or exposure is rare. This is similar to a **cross-sectional** study, where population data is summarized at one specific point in time.

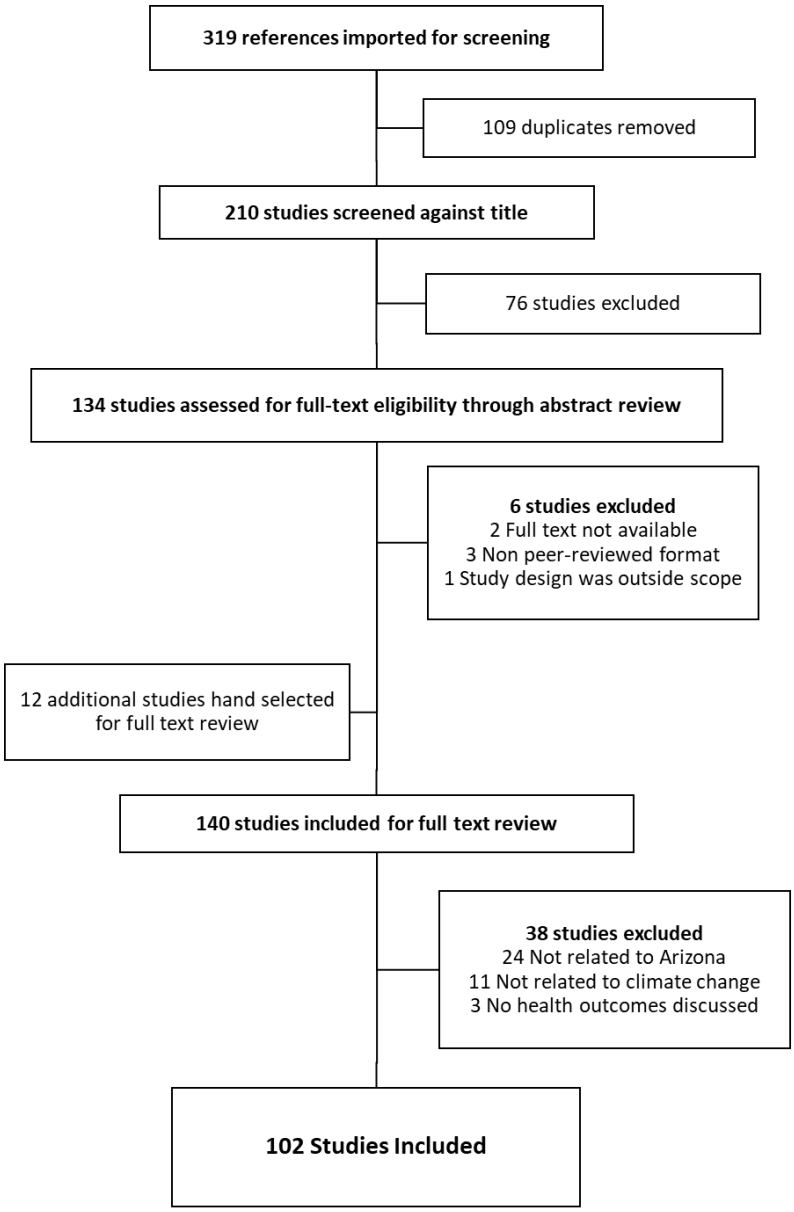
In a **systematic review or meta-analysis**, the scientist combines data from a specific set of studies to understand the overall risk or proportion of a disease. This is slightly different than a **review** which aims to summarize the research literature, similar to what we did here.

In a **case-control** study, the scientist compares two groups of participants simultaneously to determine their exposure (cases) or non-exposure (controls) and the health outcome of interest.

Results

A total of 319 articles from the three databases were identified in the literature search. After removing duplicates (n=109), 210 titles were screened for inclusion (EA, CLA, AG). If the title did not provide enough information to discern inclusion, the abstract was reviewed. An additional 12 studies were included for full-text review based on references cited by included papers. This resulted in 140 included articles that were then subjected to full-text review (EA, CLA, AG, HN). Of these, 38 more articles were excluded. Following this, data from the 102[1–102] unique manuscripts, listed in the "References" section below, was extracted. A diagram showing the selection process is shown in Figure 1, based on the Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) Flow Diagram described by Tricco, et al.

Figure 1. PRISMA Flow Diagram for Scoping Review



Among the included studies, most utilized a disease burden model (n=39; 38.2%) or retrospective cohort (n=21; 20.4%) study design. No prospective cohort, randomized controlled trials, or nested case-control studies were found. Studies were conducted from 1950-2019 with an average length of study duration of 9.25 years (Range 1 month-64 years). The majority of studies occurred in Maricopa County (n=54), followed by Pima County (n=14). Thirty-one studies used all of Arizona or included Arizona in studies of the Southwest (n=12). [Table 2]

Table 2. Study characteristics for 102 Included Studies

Study Design (see Side Box for descriptions)	N (%)
Disease burden/models/surveillance estimates	39 (38.2)
Retrospective cohort	21 (20.4)
Ecological	9 (8.8)
Cross-sectional	8 (7.8)
Review	6 (5.8)
Case-control	2 (1.9)
Other[1]	17 (16.5)
Years of Study	
Range	1950-2019
Length of Study Duration (n=70)	
Mean	9.25 years
Range	1 month – 64 years
Region or Arizona County with the main city or cities (multiple select)	
Southwest[2]	12
All Arizona	31
Apache County (St. John's)	2
Cochise County (Bisbee)	0
Coconino County (Flagstaff)	1
Gila County (Globe)	0
Graham County (Safford)	0
Greenlee County (Clifton)	0
La Paz County (Parker)	0
Maricopa County (Phoenix, Scottsdale, Tempe)	54
Mohave County (Kingman)	1
Navajo County (Holbrook)	1
Pima County (Tucson, Vail, Oro Valley)	14
Pinal County (Florence)	2
Santa Cruz County (Nogales)	1
Yavapai County (Prescott)	2
Yuma County (Yuma)	1
Other[3]	5

[1]Other Includes: Book (2), Interview and Mixed Methods (5), Conference review (1), Mathematical model (3), Economic analysis (1), Report (2), Case studies (3)

[2]All articles had to include Arizona or the Southwest. States specifically referenced in the Southwest category include: Arizona (7), California (6), Colorado (4), Nevada (6), New Mexico (8), Utah (6), Oregon (2), Washington (2), Idaho (2), Montana (2), Wyoming (2), Unspecified (2), with the criterion "In full sun with average to dry conditions from 5,200 to 8,000 elevation" (1)

[3]Entries for Other include United States (1), World Estimates (2), USA and Other countries (1), and Maryland (1). All 5 entries discuss Arizona or have impacts on Arizona-specific extreme weather health outcomes (e.g. the Maryland article discusses the establishment of ragweed pollen which also impacts air quality in Arizona).

Climate Change and Health Outcomes

Six studies [41,42,51,56,75,96] completed reviews on climate change and health outcomes in Arizona. Climate change effects reviewed included extreme heat (2), air quality (1), impacts to vectors (2), extreme weather events (2), the built environment (1), adaptation (1), and urban growth (1). The health outcomes that the reviews covered were vector-borne disease (1), infectious diseases (1), alternative transportation (1), general health outcomes (3), and preterm birth (1).

Table 3 shows a color ramp from yellow (least) to green (most) of papers for each climate and health outcome. Boxes in grey are gaps where we would not normally expect papers to be published, whereas boxes in white with a 0 are true gaps. Boxes highlighted in a bold black box show important gaps that represent opportunities for future research, with the selection based on the potential for improving human health.

Table 3. Heat Map of Climate and Health Outcomes

Climate Change Impacts	Health Outcomes: HRI and Death	Asthma and Resp. Conditions	VBDs	Valley Fever	Morbidity & Mortality	Cardiovascular Health	Malnutrition	Alternative Forms of Transportation	Mitigation Effects	Other
Heat	44	3	5	3	20	2	0	2	6	10
Air Quality	4	18	4	2	15	7		1	1	10
Impacts to Vectors	4	2	11	4	6				1	1
Extreme Weather Events	2	7	4	8	7	2	0	0	1	8
Water Management, Supply, Quality	1	0	1	0	1	0	0		2	5
Built Environment	7	1	0	0	3	1	0	0	3	3
Adaptation Mitigation or Interventions	13	2	3	2	7	0	0	0	4	6
Impacts to Food Supply	1	1	1	0	0	1	1	1	0	2
Occupational Health	3	0	1	0	2	0	0	0	1	0
Other	1	1	0	3	0	0	0	0	0	2

The majority of articles reviewed focused on extreme heat and air quality and their impacts on health. These findings are expected as extreme heat and air quality are the two major climate-sensitive hazards in Maricopa County, where the majority (estimated 63%) of residents in Arizona reside. The review also found two areas with large gaps in research in which we would expect research to be completed. The two areas of research that currently have gaps as it relates to climate and health are adaptation, mitigation, or interventions as it relates to individual/population health and occupational health as it relates to climate. In the future, we expect research to fill in these two gaps. There are currently projects happening around the areas of adaptation, mitigation, and interventions as it relates to climate and health. However, these projects are in the pilot stages and/or newly established projects that have yet to yield results for publishing.

Table 4. Adaptation, Mitigation, and Interventions by County

	Built Environment	Adaptation-Mitigation or Interventions	Alternative Forms of Transportation	Mitigation Effects
All Arizona	1	5	1	3
Apache	0	0	0	0
Cochise	0	0	0	0
Coconino	0	0	0	0
Gila	0	0	0	0
Graham	0	0	0	0
Greenlee	0	0	0	0
La Paz	0	0	0	0
Maricopa	11	12	0	5
Mohave	0	0	0	0
Navajo	0	0	0	0
Pima	1	3	0	0
Pinal	0	1	0	0
Santa Cruz	0	0	0	0
Yavapai	0	0	0	0
Yuma	0	1	0	0

Table 4 shows a color ramp from yellow (least) to green (most) of papers for adaptations, mitigations, or interventions by county.

Discussion

The study designs and types of studies we found in our literature review cover a broad range of climate and health outcomes but with significant gaps by jurisdiction and in areas of concern for the projections of climate change in the future for the region. We found, as expected, no Randomized Controlled Trials (RCT) in our search because RCTs are typically not utilized in climate and health research. We also found, as expected, that the majority of the work around climate and health pertained to Maricopa County which has a larger health department budget as compared to other counties for these activities due to population size. One benefit of the prolific work relating to Maricopa County in these areas is that other local jurisdictions can take what worked and replicate it taking into account their local environment. The long study duration that we saw is expected because many of the papers used projections of disease burden models. These study types were using decades of historical data or were forecasting many decades into the future.

One limitation we found is the gap in peer-reviewed research on alternative forms of transportation in Arizona. This could be an artifact of the databases we used to complete the search and is not encompassing the many efforts taking place to encourage the use of alternative forms of transportation. Reports on alternative transportation efforts can typically be found in grey literature, or public reports. Adaptation, mitigation, and interventions are vital to keeping the population of Arizona healthy when it comes to climate hazards. Although there are gaps in research in the areas

of alternative transportation and mitigation effects there are many efforts taking place in Arizona. Many of the efforts are happening in Maricopa County and the areas of the built environment and adaptation mitigation or interventions. Although there are many efforts in Maricopa County, we are still lacking in peer-reviewed research efforts around alternative forms of transportation. Future research and reviews should take this into account when developing their search criteria.

Another limitation and gap we found was peer-reviewed research on occupational health outcomes due to climate hazards. The three main health outcomes we saw gaps were found in asthma and respiratory conditions, Valley Fever, and cardiovascular health. Given the disease burden projections of Valley Fever in Arizona, this could be a significant gap for researchers to fill. Studies within this gap analysis might have taken into account cardiovascular health outcomes while analyzing heat related illness and death data as heat does exacerbate underlying cardiovascular conditions. However, this was outside of the scope of this project, and data were not collected on individual study analysis results. Therefore this gap may not be a true representation of the research completed in Arizona.

Conclusions

In conclusion, the majority of articles reviewed focused on extreme heat and air quality and their impacts on health. Also, the analysis identified two categories of gaps: (a) adaptation, mitigation, or interventions as it relates to individual/population health in Arizona, and (b) occupational health as it relates to climate within Arizona. Although adaptation, mitigation, or intervention was identified as a gap in research, continued efforts in Arizona through county projects funded through the AZ BRACE program are underway. Lastly, we are still lacking in peer-reviewed research efforts around alternative forms of transportation and occupational health. Although this study did not include an analysis specific to vulnerable populations, the authors recognize the importance of this topic for future research studies.

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