A Case Study on U.S. City Action Towards Protecting Homeless Lives from Heat Vulnerability

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A thesis submitted by to the
University of Colorado Boulder
In partial fulfillment
of the requirements to receive
Honors designation in
Environmental Studies

Defense Date: April 5, 2022

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Abstract

Vulnerability to times of extreme heat and heatwaves vary by social and socioeconomic groups. The particular group studied in this research is homeless populations. I examined sources outlining vulnerabilities to heat compared to sources covering homeless vulnerabilities. The vulnerabilities homeless people experience to extreme heat and heat waves is defined in this paper. The scope is divided between homeless populations exposure rate and adaptive capacity. The vulnerabilities of homeless populations defined represent higher exposure rate to extreme heat and lower adaptive capacity to extreme heat by homeless communities compared to housed communities.

A case study on two U.S. cities was conducted through policy research on heat mitigation strategies. These cities are Phoenix (AZ) and Philadelphia (PA). I compared the cities' actions to the vulnerabilities experienced by homeless communities. This comparison highlights where cities are successful or fall short in protecting the lives of homeless populations. The city of Phoenix's new Office of Heat Response and Mitigation has set plans that will reduce homeless vulnerabilities. The city of Philadelphia has more resources for cold weather events, rather than hot weather events, but their Code Red initiative has potential to be successful if it is implemented similarly to Philadelphia's Code Blue.

Acknowledgments

I would like to extend my gratitude towards everyone who has helped me towards producing this thesis. To my committee: Dr. Pielke jr., thank you for your guidance, wisdom and supervision; Dr. Brooks, thank you for your coaching and encouragement; and Dr. Kopiekin, thank you for your patience and enthusiasm.

I want to acknowledge my incredible support systems. To my friends and roommates, thank you for listening to me talk about this thesis for hours. Your reassurance has meant the world to me! To my family, your love and encouragement has helped me reach my potential. Mom, Dad, and Billie- you are my motivation, I love you!

And finally, I would like to acknowledge the homeless population of Boulder, Colorado. You have given me your time and your kind words. We have shared laughs, tears, and stories together. I see your humanity and I acknowledge your burdens and struggles in this world. I wish every homeless person I have had the pleasure to come across the resources to survive and escape the cycle of homelessness.

1. Introduction

The scientific community entirely accepts that the effects of climate change are causing rising temperatures in American urban areas. As a result, local governments are forced to consider heat mitigation strategies for their cities. Current city action towards public safety during times of extreme heat leave out an entire population of people— those experiencing homelessness (Bernard et al., 2004; Uejio et al., 2011). In doing so, homeless people are invisible in the eyes of the cities they inhabit, suffering and dying in the streets, with little aid. Homeless populations are more vulnerable to extreme heat due to the vulnerabilities in exposure and adaptive capacity. Due to this, city action to mitigate heat must respond to the vulnerabilities homeless people have to heat.

The United Nation's Intergovernmental Panel on Climate Change (IPCC) characterizes vulnerability as adaptive capacity, sensitivity, and exposure (O'Brien et al., 2004). O'Brien et. al (2004) describes adaptive capacity as the ability for a system to adjust or cope with climate stressors (O'Brien et al., 2004). They define sensitivity as the degree to which a system will respond to a change in climate, and exposure as the magnitude to which a system feels climate stressor events (O'Brien et al., 2004).

This paper outlines the vulnerabilities of homeless populations to extreme heat due to their limited adaptive capacity and large exposure rates. Specifically, a literature review will cover the prior research on extreme heat in respect to homeless people's vulnerabilities. This literature review enabled me to create a framework that defines the specific vulnerabilities homeless people experience to extreme heat. Further, this framework categorizes the vulnerabilities so that cities can best respond to areas specific to the needs of their community. Following this is a case study on American cities' action. This case study aims to highlight what actions the city of Phoenix and the city of Philadelphia are conducting to lessen the vulnerabilities to heat felt by homeless communities. The next section, prior to the literature review and case studies, will frame my methods of conducting the literature review and the case studies.

In this paper, the homeless populations are categorized as primary homeless populations. Primary homeless populations are those that live on the streets, in cars, or in temporary shelters, this excludes secondary homeless people— homeless shelter residents, temporarily with family/friends, or hopping between shelters— and it excludes tertiary homeless people— those

in long-term temporary housing (City of Melbourne, 2015). Homeless people are residents of their city and deserve to be recognized in policies affecting their wellbeing. People experiencing homelessness are the most exposed to weather and "the social and economic problems caused by extreme weather and climate change and variability" (Gronlund et al., 2018; Kidd et al., 2021). There is a growing need for cities to create plans to protect their lives, and this paper comparatively analyzes two different American cities' strategies for mitigating extreme heat for their homeless communities. These cities are Phoenix (AZ) and Philadelphia (PA). This paper's objective is to understand homeless population's vulnerability to heat, and gauge U.S. cities' efforts for heat mitigation of the homeless populations.

Before research for the thesis started, I conducted unstructured discussions with homeless people. The individuals' identity, information, and stories are not included in this paper. These people were not coded nor used for data in research. Rather, the interviews were used as a guide for prioritizing research. The majority of these discussions were conducted on the streets of Boulder, Colorado.

2. Methods

Research for this paper included three stages. Stage one is reviewing existing literature, stage two is policy analysis, stage three is comparing existing policies with vulnerabilities felt.

The first stage of gathering data was conducting research through narrative reviews of literature. The data bases used for collection of literature were "OneSearch" via University of Colorado Boulder Libraries, and "Google Scholar." The terms used for searching included but not limited to: "homeless/homelessness," "heat/extreme heat/heat waves," "heat mitigation," "heat vulnerabilities," and the two respective cities. The literature reviewed contributed to defining extreme heat implications and the vulnerabilities of homeless populations to extreme heat. The types of literature reviewed were research papers, climate data, peer reviewed articles, city policy journals, city climate action plans, and homeless shelter data resources. In the appendix, all references noted with an asterisk (*) are a part of the literature review.

A flow chart was created to visually present the vulnerabilities found. The two major categories in the flow chart are Exposure Rate and Adaptive Capacity, both sourced from the UN's IPCC definition of vulnerability. Within Exposure Rate, the two subcategories were

distinguished as internal and external to a homeless individual; Health Implications are internal to an individual, and Environmental Barriers are external to an individual. The subcategories under the Adaptive Capacity section were defined using the UN's IPCC definition of adaptive capacity.

Policy reviews were conducted as stage two of research. Policies were found through research on city and county government webpages. Many government pages provided links to homeless shelter/resource pages with more data on the cities' homeless populations. Most policies were found in annual city climate action plans. The research began with five cities: Phoenix (AZ), Philadelphia (PA), Houston (TX), Portland (OR), and Boulder (CO). Boulder was originally included as it was the site of the majority of homeless discussions leading up to the thesis. But it was not included in the end, as it is not a city on the same population scale as the other cities. Portland was initially included in the research because the city recently experienced a deadly heatwave while existing in a mild climatic region. But eventually Portland was removed from the case study due to the city size not being as comparable to Phoenix, Philadelphia, and Houston, as well as the city references being shaded by the recent heatwave, making research difficult. Houston was considered for this research as a comparison to a city similar to Phoenix, and has many other natural disasters, besides extreme heat, needing city mitigation. Houston was not a part of the final case studies due to the lack of government resources, mainly due to the city's desire to have little government footprint. Philadelphia remained in the study because it has a very similar population size to Phoenix and can be used as an example of a city who is taking action towards heat mitigation prior to heat being a large risk to the city. Phoenix was included in the study because it is a city prone to extreme heat and is on the forefront of cities being forced to mitigate heat.

After finding what policies exist, I compared the policies of stage two with the vulnerabilities of stage three. This comparison highlights the strengths and limitations of city policies to protect the lives of homeless people in times of extreme heat. A chart was created to visually show where improvement is needed.

3. Literature Review

3A. Climate Implications

As the effects of climate change are studied in depth, the impacts of climatic changes have found to be disproportionately felt. Climate change currently and predictively has a larger impact on the poor (Field et al., 2014). Extreme climate events create poverty traps for the poor, increasing their hardship (Field et al., 2014). Climate change is broader than just biogeological issues. It encompasses human rights, public health, and social equity. Shonkoff et. al (2011) highlight that without proactive policies to address the inequities of climate change, climatic impacts will "reinforce and amplify current as well as future socioeconomic disparities" leaving vulnerable populations with additional burdens and fewer opportunities for economic gain (Shonkoff et al., 2011, S499). Environmental and Climate Justice confronts the ethical proportions of climate change, acknowledging that populations with the lowest impacts towards climate change are often the first to feel the effects of climate change. Environmental action is occurring on highly unequal terms resulting in an "ecological debt" to the vulnerable populations (Francis, 2015).

The Environmental Protection Agency, as well as Field et al. (2014) outline homeless populations as at particularly high risk for extreme heat due to climate change (Environmental Protection Agency, 2016; Field et al., 2014). Shonkoff et al.'s research (2011) shows the disproportionate impacts of extreme weather events on low socioeconomic status households have "the potential to exacerbate homelessness" (Shonkoff et al., 2011, page 9). Climate change is predicted to increase the prevalence of homelessness globally, which will increase the need for policies surrounding the populations' safety (Kidd et al., 2021). Homeless populations possess some of the smallest carbon footprints yet endure disproportionately large effects of climate change (Ramin et al., 2009).

A wide dimension of environmental research found that climate change increases the frequency, intensity, and longevity of extreme heat events (Anderson et al., 2013; Rohat et al., 2021). Additionally, 91% of homeless populations live within urban settings, exposing themselves to the urban heat island effect (Ramin et al., 2009). The urban heat island effect is when low albedo (darker colored) materials replace a setting's high albedo (lighter colored) materials, resulting in less sun reflection and more sun absorption, as well as the reduced air flow

and increased car heat emissions, all resulting in an increased temperature (Environmental Protection Agency, 2016). Homeless populations find the most amount of resources for survival in urban environments, so the urban heat island effect is not a variable this population can avoid. Urban planning must consider climate implications in order to protect people from higher temperatures than what already exists in the area (Rohat et al., 2019).

Extreme heat exists during days when the apparent temperature exceeds the specific month's 95th percentile (Conlon et al., 2020). Extreme heat in the United States accounts for the greatest number of weather-related deaths than any other natural hazard, and in some years, it causes more fatalities than most weather hazards (such as tornadoes, flooding, and hurricanes) combined (Longo et al., 2017; Uejio et al., 2011). Extreme heat and heat waves generate large human health concerns and can produce fatal events, such as the 2003 French heat wave killing over 14,000 people (Anderson et al., 2013; Murray et al., 2012). As climate change increases the frequency and intensity of extreme heat and heat waves, as well as the urban heat island effect, it is vital for cities to produce plans to protect their citizens.

3B. Vulnerabilities

Homeless populations are perceived as invisible in the eyes of disaster risk planning (Longo et al., 2017; Wisner, 1998). Vulnerabilities to extreme weather events are felt different by different social and socioeconomic groups. Racial and ethnic minorities, low socioeconomic class and caste, marginalized genders and ages, physically or mentally disabled, and poor housing or lack thereof, can increase the vulnerability of a population for an extreme weather event (Murray et al., 2012). Homeless people are a part of an extremely vulnerable group (Bassil et al., 2010).

Putnam et al.'s research (2018) demonstrated just how vulnerable homeless populations are to extreme heat when they found that an increase in the number of homeless people correlates to an increase in the number of heat-associated deaths overall (Putnam et al., 2018). This research showed that an increase in temperature is not the driving force for an increase in heat-related death, instead an increase in homeless people drives more heat-related deaths.

Additionally, there is other research concluding that homeless populations are disproportionately exposed to heat with very few survival options (Bezgrebelna et al., 2021; Longo et al., 2017; Nicolay et al., 2016; Pendrey et al., 2014). Longo et al.'s (2017) policy

investigations on public infrastructure to reduce exposure to heat through warning systems and relief services again showed that the homeless people are at a particularly high vulnerability (Longo et al., 2017). Vulnerability to human induced climate change is defined in other research as a group's ability to anticipate, resist, and recover from impacts of climate change (Shonkoff et al., 2011). To understand specifically what causes people experiencing homelessness to have such a high vulnerability to extreme heat, their experiences can be categorized under exposure rate and adaptive capacity.

Exposure Rate

Exposure rate is the degree to which climatic stress is felt upon an individual or group (O'Brien et al., 2004). Exposure rates can increase or decrease depending on the frequency and intensity of extreme weather events, as well as the frequency and intensity of comorbidities occurring in the human-biological-realm and the built environment. There are very few scientific studies on the exposure rates of homeless populations, hence this review on the topic finds the intersections of other populations with homeless people. This literature review does not go into detail about the increased exposure rate due to rising temperatures because a myriad of scientific research shows that the frequency and intensity of extreme weather events is increasing due to human induced climate change.[1]

On the human-biological-realm, heat mortality is more prevalent in populations with higher levels of disability and pre-existing health implications (City of Melbourne, 2015; Pendrey et al., 2014; Putnam et al., 2018; Rohat et al., 2021; Uejio et al., 2011). Homeless populations have very high rates of disability and pre-existing health problems, involving comorbidities to extreme heat such as diabetes, pulmonary diseases, schizophrenia, and addiction (City of Melbourne, 2015; Longo et al., 2017; Uejio et al., 2011). Longo et. al (2017)'s study found that pre-existing psychiatric illness triples the threat of fatality from extreme heat, and levels of psychiatric illness are significantly higher in homeless populations than the general

[1] To explore this topic more, the studies conducted by the United Nation's Intergovernmental Panel on Climate Change, specifically in AR6 *Chapter 14: North America* sections 14.2.1, 14.2.2, 14.6, go into detail about increasing frequency of extreme heat and increasing intensity of heat related events in the United States.

population (Longo et al., 2017).[2] Uejio et al.'s research (2011) mentions how heat mortality increases with higher levels of disability, but the amount of medical care can modify the statistical relationship (Uejio et al., 2011). Homeless populations receive very little medical care and experience high levels of disability, so they are at an increasing risk for heat mortality. Often, addiction to alcohol and other drugs results in lack of spatial/social/atmospheric awareness as well as increased dehydration– which exacerbates oblivion, other medical issues present, and heat-related morbidities (Goulem, 2021).

The built environment can also exacerbate the exposure rate to extreme heat. The urban heat island effect results in increased temperatures in urban areas, the residency of the vast majority of homeless people. Rohat et al. (2021) present research on how heat-related vulnerability for populations is increased without access to air conditioning (Rohat et al., 2021). Homeless populations do not have access to air conditioning unless they are allowed into public spaces with air conditioning. Additionally, Uejio et al. (2011)'s research highlights waste heat, and how heat generated by air conditioning contributes to the urban heat island effect and can increase heat exposure for households (or individuals) without air conditioning (Uejio et al., 2011). More vulnerabilities to increased exposure rate can be found in homeless sleeping habits.[3]

Adaptive Capacity

The ability for one to adjust and cope to their changing environment is their adaptive capacity (O'Brien et al., 2004). Hondula et al.'s research (2015) on adapting to rising temperatures mentions that the relationship between extreme heat and health concerns is seemingly straight forward until the complexity of human's ability to adapt is considered (Hondula et al., 2015). Homeless populations have very limited ability to adapt, highlighting the link between their health outcomes and rising temperatures.

The ability to adapt is measured in one's capacity to anticipate risk, respond to risk, and recover/change (Murray et al., 2012). To anticipate risk, the United Nation's Intergovernmental Panel on Climate Change (IPCC) suggests planned efforts such as diversifying income sources

[2] Additionally, many of these health issues cause the person to become homeless due to the costly requirements to stay ahead of their health implications.

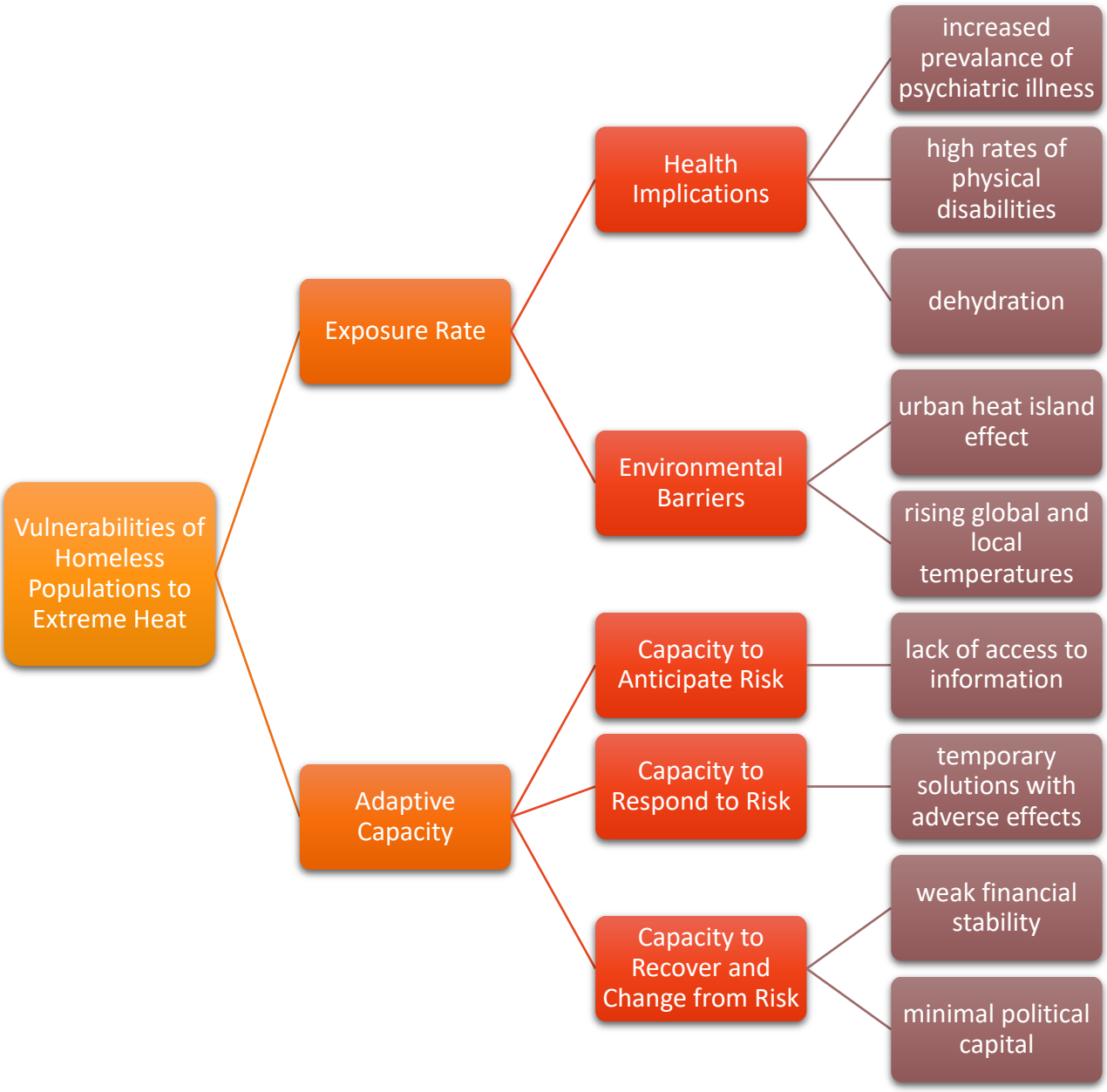
[3] Falling asleep or lying for extended periods in the sun, sleeping in the sun with multiple layers on, and being mistaken for peacefully sleeping when they are actually in a severe heat stress situation (City of Melbourne, 2015).

and collective action towards avoiding high risk development (Murray et al., 2012). Homeless people have miniscule income, not enough to diversify, and have a weak social capital, posing difficult to participate in mitigating large risk management. Additionally, to anticipate risk, easy access to information is required. Populations that lack access to information are more prone to injury and death (Wisner, 1998). Homeless populations do not have easy access to weather forecasts, as well as Mukarram et al.'s research presents that 55% of homeless individuals surveyed could not identify the symptoms associated with heat related illnesses (Mukarram et al., 2021).

The capacity to respond to risk involves temporary solutions to mitigate climate stresses (O'Brien et al., 2004). Most homeless individuals have this capacity, but it is weak. Homeless individuals seek shade, a water source, or an air-conditioned public space. Other temporary solutions can have adverse effects, such as spending money to cool down when it was originally saved for food, shelter, and/or transportation (Murray et al., 2012). When a heatwave occurs in a city, homeless people are not the ones scrambling to the store to buy swamp coolers and AC units, they are in search of the bare minimum to survive. The IPCC concludes that the capacity to respond is not sufficient to reduce risk (Murray et al., 2012). Solutions need to be more permanent as the climate crisis worsens.

The capacity to recover and change is driven by many different factors such as financial ability, health ability, and political will (Murray et al., 2012). The Intergovernmental Panel on Climate Change highlights how severely limited the capacity to recover is by poverty, and this capacity can often lead to a poverty spiral, resulting in the inability to ever return to previous conditions (Murray et al., 2012). To recover, homeless people need health resources, financial stability, and a just representation in political decisions. These three factors are extremely difficult for homeless populations to gain as they are disengaged from health services, often variable income, and "cognitively invisible" in public policies (Longo et al., 2017; Pendrey et al., 2014).

Figure 1: Chart of Vulnerabilities to Extreme Heat Felt by Homeless Populations



4. Case Study on American Cities

This paper is outlining two U.S. cities: Phoenix (AZ) and Philadelphia (PA). Phoenix is selected because it resides in a climate used to very high and dry temperatures and is one of the forefronts for anthropogenic climate change induced heat risk. Philadelphia has mild temperatures and heat risk is seemingly not as urgent. Both cities have a responsibility for preparing for current and future heat crises. Phoenix and Philadelphia are studied because they have varying levels of relative urgency, with similar structures (i.e., both are cities under United States' government format).

4A. *Phoenix, Arizona*

The city of Phoenix is an ideal location to study heat risk mitigation as it is in a desert biome, experiencing warm temperatures year-round. Phoenix is arid subtropical, with summer temperatures averaging, in the last 30 years, at 106.5º Fahrenheit highs and 84.5º Fahrenheit lows (NOAA, 2021; Uejio et al., 2011). In July of 2021, the City of Phoenix announced an addition to their government: Office of Heat Response and Mitigation. This is the first of its kind, and a large step towards mitigating human-environmental risk.

In Guyer et al.'s research on heat risk in Phoenix, they found specific risk factors that exacerbate the effects of extreme heat, some of these factors implicitly and explicitly involve homeless populations: low access to social services, low access to air conditioning, social isolation, excessive outdoor time, limited knowledge of resources available, mental and physical health issues, and homelessness (Guyer et al., 2019). During a 2005 extreme heat event, Phoenix coroners identified two-thirds of the mortality cases as homeless people (Uejio et al., 2011). Phoenix resides within Maricopa County and makes up the majority of its residents. An extensive mortality report on Maricopa County provided statistics on homeless deaths. In 2020, Maricopa County found:

- 97% of homeless deaths were outdoors (Maricopa County Public Health, 2020)
- 53% of heat related deaths were homeless people (Maricopa County Public Health, 2020).

- Of the 323 heat related deaths in Maricopa County in 2020, 58% involved substance abuse, and of that, 82% of those people were homeless (Maricopa County Public Health, 2020).
- Of the 323 deaths, 37% were in the range of 60-64 years old, and 60% of those people were homeless (Maricopa County Public Health, 2020).

The majority of homeless deaths (56%) occurred in July— 76 homeless people died within the 20-day period of July 2-21, 2020— and 31% died in August – 26 homeless deaths between August 13-21, 2020 (Maricopa County Public Health, 2020). These two months contain the highest temperature days for Phoenix. Homeless population measurements with heat are lacking representation and can be found cited in multiple Phoenix studies under the limitation or further research needed areas (Uejio et al., 2011).

In a policy review of the city's actions towards protecting homeless people from the detriments of extreme heat, the new Office of Heat Response and Mitigation for Phoenix outlined their key missions in mitigating heat: Cool Pavement Program, Tree and Shade Master Plan, and Citizen Forester (Hondula et al., 2021). The Cool Pavement Programs aims to increase albedo in the city by replacing dark pavement materials to lighter ones (Hondula et al., 2021). The Tree and Shade Master Plan aims to increase forestry in the city, to increase the number of shaded regions, and in turn to help reduce the temperature felt in the city (Hondula et al., 2021). The Citizen Forester is a program to educate the community on importance of planting trees (Hondula et al., 2021). Phoenix's Office of Heat Response and Mitigation outlined their key missions in response programs: We're Cool Campaign, Heat Relief Network, and "Take a Hike, Do It Right" campaign (Hondula et al., 2021). The We're Cool Campaign is designed to inform low-income residents about the city's 44 cooling and hydration centers (Hondula et al., 2021). The Heat Relief Network is for city partners to provide hydration stations, cooling centers, and donation drives throughout the city (Hondula et al., 2021). This initiative could be beneficial in allowing for effective community-based help, as Berisha et al. (2017) found that the limiting factor to longer hours for cooling centers in Phoenix is the lack of monetary support to allow for extended worker hours to support independent efforts (Berisha et al., 2017). The "Take a Hike, Do It Right" campaign involves City Park Rangers assisting in heat safety measures (Hondula et al., 2021). Additionally, the city defined 5 actionable goals for mitigating city heat (City of Phoenix, 2021; Hondula et al., 2021):

1. Create a network of 100 cool corridors in vulnerable communities by 2030.
2. Increase shade (trees/constructed) in 'flatland parks' and street right of way to achieve 25% canopy by 2030.
3. Provide resources and services to residents to manage heat.
4. Increase the use of high albedo, or reflective materials in infrastructure projects.
5. Develop "HeatReady" certification for cities in partnership with ASU by 2025.

In Phoenix's 2021 Climate Action Plan, there is no mention of homeless populations at all (City of Phoenix, 2021). But they did dedicate an entire section to environmental justice. In this section, the plan outlined 6 key values for all climate action: (1) Equitable Representation (2) Prioritizing Benefits, (3) Economic Impacts, (4) Health Impacts, (5) Access to Solutions, and (6) Building Resilience (City of Phoenix, 2021)[4]. The 2021 Climate Action Plan conducted surveys and workshops to better gauge the needs of Phoenix residents in regard to climate action (City of Phoenix, 2021). These efforts are pro-active towards combating the effects of climate change in Phoenix, but still do not include the perspective nor acknowledgement of homeless communities in Phoenix.

4B. *Philadelphia, Pennsylvania*

The city of Philadelphia is in humid subtropical and humid continental climatic zones with variable weather patterns and warm summers (Uejio et al., 2011). A study by Weber et al. (2015) found that from 1980-2013, the number of extreme heat days in the city of Philadelphia

[4] Key values for Phoenix's Climate Action Plan as defined in the 2021 plan (City of Phoenix, 2021):
(1) Equitable Representation: "The Climate Caption Planning process should provide easily accessible opportunities for any interested person to participate."
(2) Prioritizing Benefits: "Climate Action Planning strategies with the potential to provide benefits to individuals or communities, overburdened communities should be prioritized."
(3) Economic Impacts: "Climate Action Planning strategies should reduce costs, including currently externalized costs, and increase economic benefits for overburdened communities wherever possible."
(4) Health Impacts: "Climate Action Planning strategies should minimize negative health impacts and increase health benefits for disproportionately impacted communities."
(5) Access to Solutions: "Climate Action Planning strategies should promote clean technologies in ways that are equitable for all living in Phoenix."
(6). Building Resilience: "Climate Action Planning strategies should improve resilience and quality of life for overburdened communities."

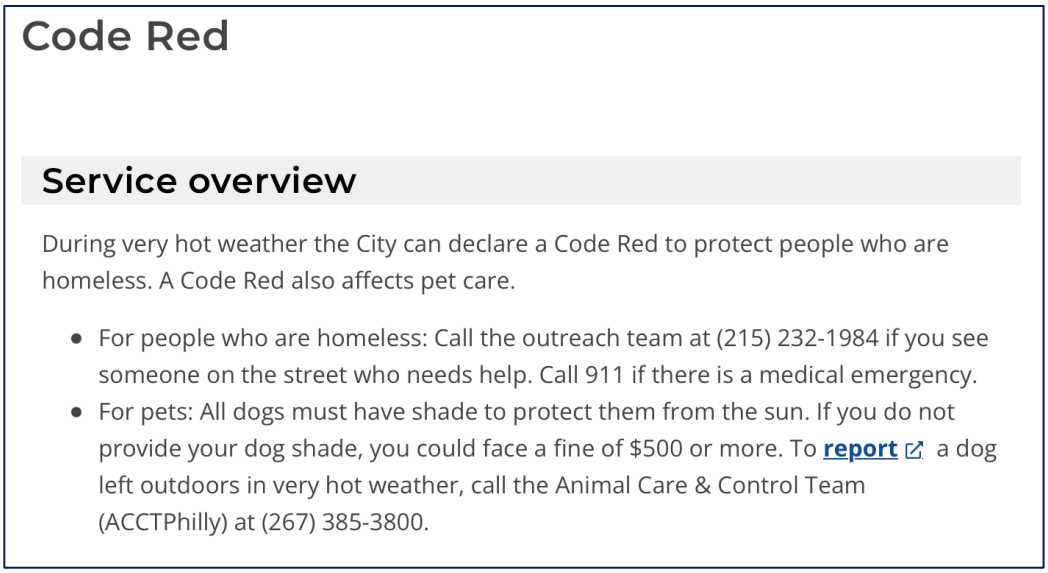
increased from 4 days to 12 days, while the surrounding non-urban area has remained at about 5 extreme heat days per year (Weber et al., 2015). Relative to cities such as Phoenix and other southern U.S. cities[5], Philadelphia does not seem to have extreme heat as a high risk to the city's residents. During the winter, Philadelphia has regular winter storms, and the city has built initiatives to address homeless populations during these storms (Farley et al., 2017). During December through March, Philadelphia activates "Code Blue" when temperatures are reported below 20º Fahrenheit (-6.6º C), or below 32º Fahrenheit (0º C) with precipitation (Farley et al., 2017). Code Blue entails increased emergency housing beds, extended hours for homeless outreach, court-ordered transportation of homeless people to shelters, and prohibition of eviction from emergency shelters (Farley et al., 2017). This initiative has proven to be successful in saving the lives of homeless people from cold weather events (Farley et al., 2017).

A policy review of Philadelphia's efforts to combat homeless vulnerabilities to extreme heat found few policies. Similar to the Code Blue efforts, Philadelphia has a Code Red for summer months. Below is a screen capture of the Code Red policy from the Philadelphia government website—this screenshot is the extent to which Code Red is explained/discussed by the Philadelphia government:[6]

[5] In an urban climate simulation conducted by Rohat et al. (2021), Houston's summer temperatures averaged at 24.7º Celsius (76.5ºF) and is predicted to increase to a range from 26.2-27.1º Celsius (79.1-80.8ºF) in 2050 (Rohat et al., 2021). The highest fatality weather event in the state of Texas is heat, and Harris County, the county Houston resides in, has the highest amount of heat fatalities in the state (Paul et al., 2018).

[6] If there was more time for research, efforts to interview Philadelphia government workers and citizens on their knowledge about Code Red, when it is activated, how effective it is, and what specifically it does, would be a part of the research methods on this policy.

Figure 2: Screenshot of Code Red policy from Philadelphia's government page (Phila.gov).



Besides Code Red, the city of Philadelphia has cooling centers, hydration stations, and spray grounds. Spray grounds across Philadelphia almost all exist on children's playgrounds, which is an area that homeless communities do not frequent during the day, as for increased shaming and perceived danger towards children. Within the city, there are 10 cooling centers and 3 cooling bus stops (City of Philadelphia, 2021). The hydration stations are not marked on a map. Other than these initiatives, the city has information pamphlets, including information encouraging frequency in city libraries and museums on hot days, reminders to stay hydrated and out of the sun, and the warning signs of heat exhaustion and heat stroke (Foizen, 2016; Ready or Not Philadelphia, 2015).

In the city's Climate Action Playbook by the Philadelphia Office of Sustainability, there are plans to reduce the city's climate impact. Most of the solutions involve adjusting the energy grid in the city to be more efficient, used less often, and transitioning away from fossil fuels (Greenworks Philadelphia, 2021). This plan also included waste reduction and increased use and efficiency of public transportation (Greenworks Philadelphia, 2021). In respect to heat mitigation for homeless populations, inadvertently, plans to develop an Urban Forestry plan and develop a Citywide Climate Resiliency Strategy, will protect homeless individuals to extreme heat (Greenworks Philadelphia, 2021). These two plans are not yet occurring but are currently in development or planned to be developed soon.

4C. Comparison of Vulnerabilities to Current City Policies

The figure below compares the vulnerabilities of homeless people to extreme heat, defined in section 3B, to the cities' policies in place to address heat mitigation, highlighted in section 4A and 4B. If no action is taken, the city is ranked poor (○). If there is city planning underway but not complete, the city is ranked inadequate (◔). If city planning is complete but implementation has not yet started, the city is ranked adequate (◑). If the city implemented solutions, but more action is needed to meet homeless needs, the city is ranked good (◕). If the city has fully implemented a solution that meets the particular vulnerability needs of the community, the city is ranked exemplary (●).

Figure 3: Comparison chart of vulnerabilities of homeless people felt with city actions on heat mitigation.

Vulnerabilities[7]	**Phoenix, Arizona**	**Philadelphia, Pennsylvania**
Accessible Cooling and Hydration Centers	●	◕
Initiatives to Reduce Urban Heat	◕	◔
Accessible Heat Preparation Resources	◕	◕
Involvement of Homeless Perspectives in Policy Creation	○	○

Fig. 3 Legend: ○ = poor, ◔ = inadequate, ◑ = adequate, ◕ = good, ● = exemplary

[7] This chart is based on the vulnerabilities defined in Figure 1. Some vulnerabilities are left out from this chart, as they are out of the scope of research. For example, the increased prevalence of psychiatric illness and physical disabilities in homeless populations would be addressed by health outreach initiatives, not heat mitigation.

5. Discussion

5A. City Comparison

In Figure 3, the comparison between the vulnerabilities and city action highlights the actionable items cities can do to address homeless vulnerability to heat. Phoenix addresses most of the vulnerabilities, except for involvement of homeless perspectives in policy creation. Philadelphia is not meeting the needs of their homeless populations to heat, as most of their initiatives involve cold weather. Both cities lacked any participation of homeless voices in policy creation.

Phoenix needs to be further along in heat mitigation implementation compared to Philadelphia due to the higher urgency in Phoenix. This chart does not show one city as being better prepared than the other, since it is expected that Philadelphia does not view heat as an imminent threat. Further research can be conducted to rate the level of urgency a city faces from heat compared to their heat mitigation strategies, as to understand how cities' rank in heat mitigation success. Since urgency varies across cities, having a risk scale on this chart would allow for a better understanding of whether a city is performing well enough to protect homeless lives to extreme heat.

5B. Recommendations

Ensuring there is environmental justice for the homeless communities, solutions should address the three dimensions of environmental justice: distributive justice, procedural justice, and justice of recognition. Distributive justice is provided through equal and accessible resources for all homeless people during times of extreme heat. Distributive justice would be found in more resource centers and easy access to relevant heat information. Gronlund et al. suggest increasing the number of cooling centers as a short-term solution to heat mortality (Gronlund et al., 2018). Along with the increased cooling centers, there needs to be hydration stations readily available.

In order to know when and how to use cooling centers and hydration stations, homeless individuals need easy access to information about impending heat waves, locations of cooling

centers, locations of hydration stations, and hours of operations for those and other support systems. Additionally, homeless populations need easy access to information about what heat sickness looks like, when to seek help, and other survival information about incoming extreme heat events. Without accessible information on how to utilize the help centers or when to seek aid, homeless people will not receive distributive justice. Both Phoenix and Philadelphia have informational pamphlets about what heat illness looks like and how to avoid it. But these pamphlets are in the perspective of those living in houses. There needs to be informational guides for homeless people, as the non-homeless perspective guides include many survival tips that are inaccessible or unattainable to homeless people.

To guarantee procedural justice, homeless voices must be a part of city decision making on policies that effect their lives. As Wisner highlights in the discussion of his findings, policy planners cannot fully understand the needs of marginal populations unless the population is invited and encouraged to speak up (Wisner, 1998). Wisner also recognizes that there are many obstacles between full participation of marginal groups on policy development, and it is the job of the policy planners to clear the obstacles (Wisner, 1998). To increase homeless voices in policy developments, outreach and accessible workshops are necessary.

In 2018, Arizona held a workshop to increase connections of individuals and agencies working to mitigate extreme heat impacts (Guyer et al., 2019). The workshop was mostly successful, but Guyer et al. (2019) notes that there are still gaps remaining for the best practices towards heat preparedness and response (Guyer et al., 2019). Gaillard et al. (2019)'s research on homeless people's experience with natural hazards found that establishing dialogue between stakeholders, which they define as including homeless people, is essential in understanding and securing the resources required for homeless population's safety and livelihood, especially since they experience unique precarities (Gaillard et al., 2019).

Additionally, Gaillard et al. acknowledge that the locations homeless people frequent (parks, churches, support centers/services, and footpaths for hustling), are temporary in the individual's transient lifestyle, as homeless people tend to seek sites that are discrete and secluded (Gaillard et al., 2019). This makes outreach difficult as individual's locations are unknown to the public and unknown even within the individual's social network (Gaillard et al., 2019).

A lot of policy development is through analytics that tend to exclude homeless people (Longo et al., 2017). Without a smart phone, bank account, credit card, or regular internet connection, the networks of sensors and monitors do not capture the data of homeless people, rendering them invisible in any analytic approach to policy development and biasing all data against their interests (Longo et al., 2017). Additionally, Bassil et al.'s research on reducing morbidity and mortality to heat found that "telephone and postal surveys and face-to-face interviews that recruit participants at public places such as shopping plazas, typically in suburban rather than urban areas, do not capture important vulnerable groups like the socially isolated and homeless" (Bassil et al., 2010). Through my research, I cannot advise the best practices for effective homeless outreach and consideration, but nonetheless, homeless individual outreach efforts should be a crucial step in policy development.

Justice of recognition can be provided through the acknowledgment of homeless people as a population of city residents in policy planning. In Phoenix and Philadelphia, homeless populations were not included as a crucial resident population, sometimes not even mentioned at all, in climate action plans. Providing the basic human desire of recognition of humanity is necessary in providing justice to homeless populations.

5C. Limitations

The largest limitation to this thesis is lack of prior research. City governments lack concern for homeless people and heat, resulting in little information provided. If given more time to conduct this project, interviews, risk assessment, and inclusion of other cities would be added. Interviews with homeless people in Phoenix and Philadelphia would add to this paper through a first-hand perspective on whether city policies are effective in meeting their needs. Additionally, interviews with members of the city governments would provide more information on policies than what the government web pages provide. Specifically, I am interested in the details and effectiveness of Code Red in Philadelphia, as the web page provided very little information.

In figure 3, I believe the chart would be more effective in evaluation if there was a rank of heat-risk urgency per city. Showing the varying level of risk would allow for the cities to be compared to each other as to who is performing better. Without the addition of a measurement of

urgency, the cities cannot be compared to each other, rather they stand alone, only compared to the vulnerabilities they are responding to.

Inclusion of more cities in the case study would provide a larger view as to what different U.S. governments are doing for heat mitigation. A wider scope of city action could provide examples of effective practices for other cities to adopt. Additionally, the inclusion of global cities could aid in this effort as well. For example, the city of Melbourne (Victoria, Australia), has an extensive list of homeless vulnerabilities to heat, and how the city is addressing the problems (City of Melbourne, 2015). More research into Melbourne and other global cities could expand the possibilities of addressing the homeless vulnerabilities to heat.

5D. Conclusion

Climate change expects to have the greatest impact on populations that are already vulnerable. Homeless populations are made up of veterans, transgender people, people of color, disabled people, and more marginalized and minority populations. The vulnerability to natural hazards reflects homeless people's everyday uncertainty and invisibility, inequitably compared to the power and resources shared by the rest of society (Gaillard et al., 2019). Homeless populations are among the lowest contributors to climate change and have one of the smallest carbon footprints, yet they bear a disproportionate front end of climate change forces (Ramin et al., 2009). As a consequence of their lack of financial resources, protective permanent shelter, and basic services, homeless populations fall into a poverty trap whenever an extreme event occurs (Field et al., 2014).

Proactive versus reactive policies for vulnerable populations are a matter of life and death for homeless people. Phoenix is already experiencing high frequency of extreme heat days annually, and the need for effective policies is urgent. Phoenix succeeds at addressing the rising apparent temperature in the city, but their Office of Heat Response and Mitigation must continue reaching their goals in a timely manner. Although Philadelphia does not currently face an urgent need to respond to extreme heat similar to Phoenix, the efforts must be in place now, before a period of extreme heat hits the city. Philadelphia has cooling and hydration centers in place, but

most heat mitigation strategies are not fully developed. Policies mitigating extreme heat need to be proactive, otherwise the vulnerabilities described in section 3B will lead to the death of homeless individuals. Cities need to act eagerly and effectively on creating procedures to combat the effects of extreme heat.

6. Appendix

6A. References

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