IDENTIFYING AND ADDRESSING HEAT INEQUITIES IN THE CITY OF LOS ANGELES

2023 UCLA MURP Comprehensive Planning Project, conducted in collaboration with the LA City Climate Emergency Mobilization Office (CEMO)

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A comprehensive project submitted in partial satisfaction of the requirements for the degree Master of Urban and Regional Planning

DISCLAIMER

This report was prepared in partial fulfillment of the requirements for the Master in Urban and Regional Planning degree in the Department of Urban Planning at the University of California, Los Angeles.

It was prepared at the direction of the Department and of the Los Angeles City Climate Emergency Mobilization Office (CEMO) as a planning client. The views expressed herein are those of the authors and not necessarily those of the Department, the UCLA Luskin School of Public Affairs, UCLA as a whole, or the client."

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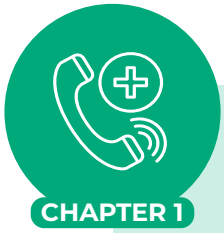
Report Overview

The climate emergency and its dire impacts on frontline communities in the City of Los Angeles inspired the creation of the Climate Emergency Mobilization Office (CEMO) by January 2021, although the idea dates back to 2019. The office, guided by the principles of environmental justice, coordinates with the Mayor and City Council, and collaborates with City departments through meaningful engagement with frontline leaders and their communities.

CEMO has also begun broader work to identify and enact equitable strategies and policies to prevent, mitigate, and undo impacts from past pollution and economic disinvestments, and to ensure that frontline communities have a strong voice in policy and decision-making in the City of Los Angeles. This work has been done in partnership with many advocacy groups, students, and scholars at UCLA including graduate-level Public Policy and Public Health students.

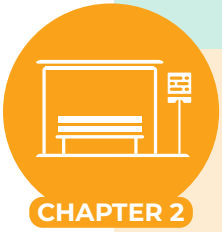
Based on conversations between UCLA Urban Planning Professor Gregory Pierce, and Marta Segura, an agreement was reached for a "Comprehensive Project." Thirteen graduate-level Urban Planning students worked with CEMO on heat equity planning and strategies over the course of UCLA academic year 2022-2023. This report reflects their efforts and the results of that partnership. The aim of this study was to identify gaps in the City's intervention strategies that focus on populations most in need during extreme heat events: those who needed to make informational or emergency calls, bus transit riders, and those without indoor cooling access.

TOP-LINE RECOMMENDATIONS



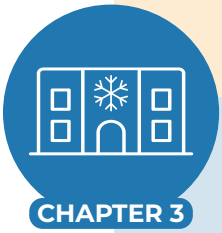
EMERGENCY CALLS

1. Use of 911, and potentially 311, call volumes as supplementary heat emergency indicator
2. Collect data on potential confounding variables (i.e., major events, employment levels, demographics) that may impact call volumes
3. Develop clear data reporting procedures to aid in more accurate future analyses
4. Incorporate city council districts into 911 data collection to facilitate smoother policy implementation
5. Create more expansive definitions of Heat Advisory and Heat Alert that use lower heat thresholds than existing City and County policy
6. Validate the use of alternative data sources to assess and manage the needs of community members during heat emergencies.
7. Develop proactive outreach and mitigation strategies for cooling resources in the hottest and most vulnerable communities of the city



BUS SHELTERS

1. Reframe bus shelters as public infrastructure supported by public investments
2. Introduce a specific and fully transparent formula for bus stop allocation and success measurement
3. Coordinate S.T.A.P. with other heat adaptation and bus shelter policy efforts in L.A
4. Consider using Local Climate Zones (LCZs) for the heat metric in S.T.A.P's allocation criteria
5. Engage residents and local stakeholders in designing and siting bus shelters



COOLING CENTERS

1. Expand the City's cooling centers network to include community resilience centers, external partnerships, and new site locations in priority neighborhoods
2. Expand access broadly to affordable and energy-efficient residential cooling for low-income and disadvantaged households
3. Develop relationships with unhoused communities and mutual aid organizations to co-develop heat responses that meet the needs of unhoused residents
4. Ensure HVAC systems are maintained and upgraded at existing cooling centers, and offer portable cooling supplies such as handheld fans and cold compresses
5. Streamline communications between City agencies, cooling center sites, and residents to optimize operations and increase community outreach

ANALYSES CONDUCTED

CLIMATE
Identifying extreme heat days in LA City from 2018 to 2022 at various thresholds from 90°F - 100°F

NON-EMERGENCY CALLS
Analyze 311 call volumes at the citywide level to assess potential impact of extreme heat on city services

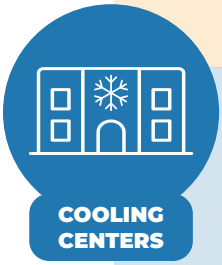
EMERGENCY CALLS
Analyze excess 911 call volumes at the fire district & citywide level to assess impact of extreme heat on LAFD response

CROSS-CITY COMPARISON
Review and summarize how other cities are using bus shelters for extreme heat adaptation

BUS STOP FIELD VISITS
Observe the current conditions of bus stops in three L.A. City Council districts (3, 5, and 14)

INITIAL S.T.A.P. FUNCTIONING
Analyze the S.T.A.P contract listing the advantages and disadvantages of a Public-Private Partnership (PPP) model for public infrastructure

CASE STUDY OF FIRST-YEAR S.T.A.P. ALLOCATIONS
Assess the equitable performance of the 1st year of S.T.A.P. shelter allocations and StreetsLA's priority ranking system in addressing the established heat vulnerabilities and shelter needs of three L.A. City Council Districts.



EXISTING CENTER CONDITIONS, CAPABILITIES, AND READINESS
Determine how well current sites operate and are able to meet the needs of high-need communities

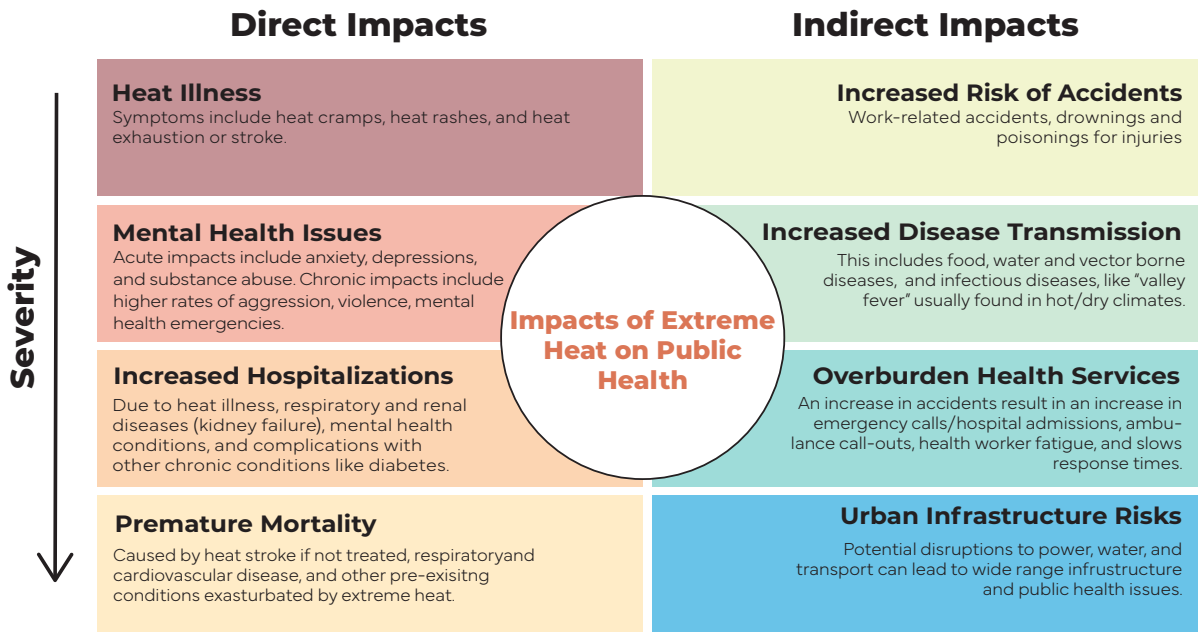
DARK SPOTS ANALYSIS
Identify neighborhoods that are lacking in cooling center access and might be prioritized for new cooling center or community resilience centers in the future

CHAPTER 1
EXECUTIVE SUMMARY

Introduction

Climate change is expected to cause more frequent and severe extreme heat events —including in the Southern California region—catalyzing researchers to explore the potential impacts on public health and infrastructure. As extreme heat events become more common and severe across the globe, literature documenting the wide-ranging physical and mental health impacts continues to grow. In addition to adverse health impacts, elongated extreme heat events can have expansive indirect impacts as shown in Figure 1, below.

Figure 1: Direct and Indirect Impacts of Extreme Heat



Extreme heat events increasingly have a significant impact on public and mental health.[1][2] More broadly, these events can lead to indirect cascading effects that

1 Sorensen, C., & Hess, J. (2022). Treatment and Prevention of Heat-Related Illness. New England Journal of Medicine, 387(15), 1404–1413. https://doi.org/10.1056/NEJMcp2210623

2 Center for Disease and Control Prevention. (nd). Warning Signs and Symptoms of heat-Helated Illness. CDC. https://www.cdc.gov/disasters/extremeheat/warning.html

impact a variety of municipal and infrastructure services. For example, increased use of AC systems in residential and commercial buildings can strain power supplies, and create disruption in power distribution[3]. Understanding how the intersectionality of extreme heat mitigation, emergency response, and urban infrastructure systems directly impacts public health outcomes is critical when developing a heat action plan for the City Los Angeles, especially for the city's most vulnerable populations.

Past studies within municipalities in Canada and the United States have used the volume of heat-related emergency department (ED) visits and hospitalizations as indicators to measure the health impact of extreme heat exposure.[4] [5] Our analysis aims to support the Los Angeles City Climate Emergency Mobilization Office's (CEMO) request to explore the potential for using excess 911 and 311 calls as alternative or complementary indicators for determining residents' exposure and response to extreme heat events. More specifically, we ask whether or not 911 and 311 call volumes increase during periods of extreme heat. By comparing both systems' call data to identify past regional heat events and heat-vulnerable populations, the City of Los Angeles may better identify communities most exposed to the impacts of extreme heat or reveal gaps in current emergency management response.

For the purposes of this report, we use emergency health information from 911 call data and the City's individual non-emergency information request call data from 311 to create a novel and more holistic analysis of the public health impacts caused by heat events. The aim with this analysis is to explore the level of public engagement with 911 and 311 call services during extreme heat events within the past five years (2018-2022).

The analysis in this chapter attempts to answer the following questions: (1) Is there a correlation between daily maximum temperature (extreme heat events) and 911 or 311 call volumes? (2) Are there excess calls to 911 and 311 systems during extreme heat events? and (3) do excess call volumes inform the City of Los Angeles regarding areas most impacted by extreme heat, and thus in need of additional emergency resources?

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3 "CAISO Warns Excessive Heat Will Stress Power Grid." Energized by Edison, 18 May 2023, energized.edison.com/stories/caiso-warns-excessive-heat-will-stress-power-grid.

4 Dolney, Tim & Sheridan, Scott. (2006). The relationship between extreme heat and ambulance response calls for the city of Toronto, Ontario, Canada. Environmental research. 101. 94-103. 10.1016/j.envres.2005.08.008.

5 Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H. G., Smith, D., Solomon, G., Trent, R., & English, P. (2009). The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environmental health perspectives, 117(1), 61–67. https://doi.org/10.1289/ehp.11594

By identifying which communities are most impacted by extreme heat events through an analysis of excess emergency and non-emergency calls, we are able to offer recommendations to the newly established Climate Emergency Mobilization Office (CEMO) and other LA City agencies that can guide how best to equitably distribute both emergency and non-emergency services.

Data and Methods

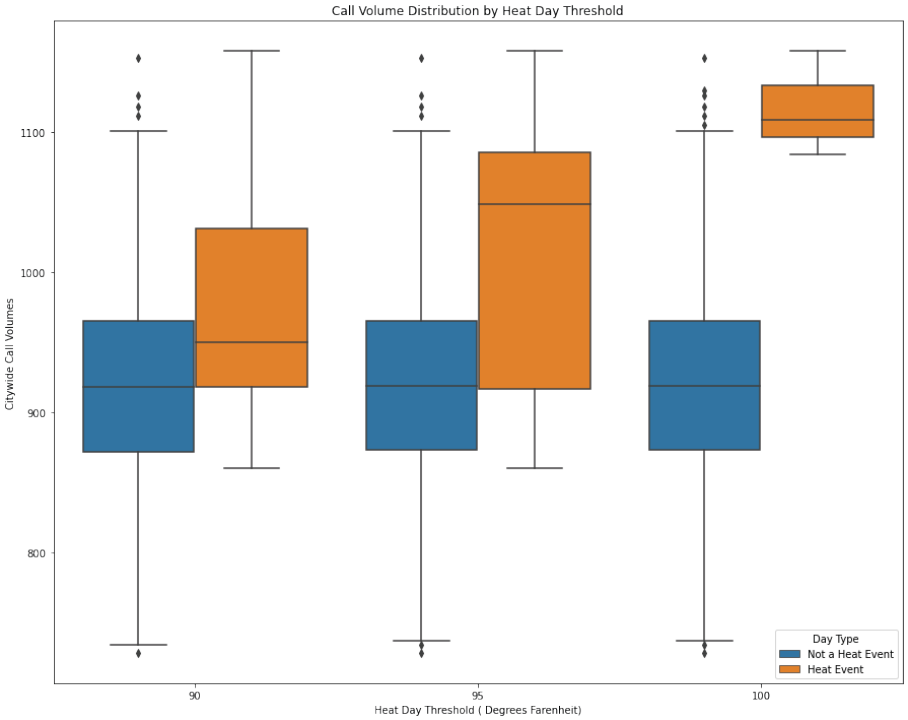
We explore novel data we obtained on 911 call volumes at the fire station district level (of which there are 102 in the city of Los Angeles) and 311 information request call volumes at the city level. These scales are reflective of the most granular data available upon request. For both analyses we constructed a daily high heat index for the relevant geography and assess whether more calls occurred during a "heat event", defined as the second or greater consecutive days of high heat (the second, third, fourth, or nth day in a row over a heat threshold). This definition of a heat event ensures our analysis is sensitive to air temperature, humidity, and the impacts of extended periods of heat. We test three temperature thresholds to define these periods of high heat: 90°F, 95°F, and 100°F. We define excess calls as the number of calls that occurred on heat days in a given fire district that were greater than one standard deviation above the average number of calls in that district on non-heat days.

To better understand the communities living in the fire districts with the highest excess call volumes, we explore this alongside vulnerability data for the seven fire districts with the highest excess calls using the Los Angeles Climate Vulnerability Assessment and compare them to the fire districts with the lowest excess calls.

Findings

We find a statistically significant correlation between 911 call volumes and daily maximum temperature across the city. This relationship holds true for 911 call volumes across the city as a whole when defining heat events as the second or greater consecutive day of heat exceeding each of the 90°F, 95°F, and 100°F thresholds tested (See Figure 2).

Figure 2: Call Volume Distribution by Heat Threshold

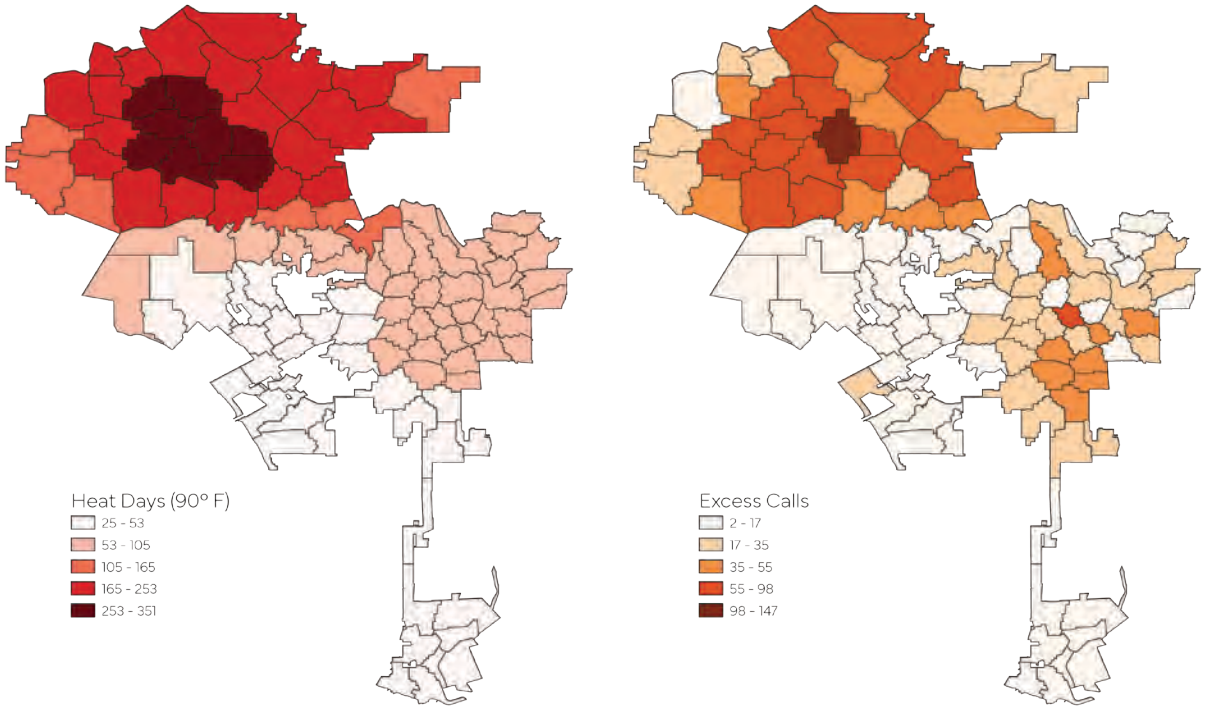


For 311 call volumes and heat, we do not find a definitive relationship. Initial regression analysis does not show an immediate relationship; however, when performing a one-sided t-test, we find that there are statistically significant greater average 311 call volumes on heat days and events over 90°F than on non-heat days.

We then use 90°F (a commonly used threshold) as the heat threshold to determine the number of excess calls due to heat. We estimate that there were approximately 3,291 excess calls due to heat in the City of Los Angeles between 2018 and 2022 when compared to the baseline of one standard deviation above the average daily call volumes in each fire station district. The distribution of call volumes across the city, shown in Figure 3, appears to manifest in a related but not parallel pattern to the number of heat days themselves.

Quantitatively, climate-vulnerability did inform the number of excess calls in addition to extreme heat. The fire districts with the highest excess call volumes during days that were 90°F or above had larger climate-vulnerable populations including children, older adults, and older adults living alone — as well as higher rates of asthma,

Figure 3: Excess 911 Calls in LA City, 2018-2022



cardiovascular disease, and disability. These fire districts also had larger percentages of renters, those rent burdened, those with no health insurance, and those living in poverty, while fire districts with the least excess calls housed smaller percentages of climate-vulnerable populations.

Recommendations

Based on these results, our main recommendations for CEMO, the city as a whole, the 911 (including LAFD, LAPD, and EMD) response system, and the 311 (ITA) response system given their roles as collaborators in developing a Heat Action Plan and delivering essential city services to residents are:

1. Consider the practical implementation steps for use of 911, and potentially 311, call data volumes as heat emergency indicators alongside existing metrics.
2. Collect additional datasets to control for confounding variables (such as calendar events, employment, demographics, and land uses) that can affect 911 and 311 call volumes during extreme heat events.
3. Develop clear data collection and reporting procedures for both 311 and 911 call centers to ensure that all data contains geographic information for future analysis.
4. Aggregate 911 calls to city council districts based upon the locations of fire stations to apply recommendations to political boundaries in addition to administrative boundaries.
5. Create more expansive definitions of Heat Advisory and Heat Alert that use lower heat thresholds (90°) than existing city and county policy (95°F in the LA Basin and 100°F in the Valleys) in order to activate additional services.
6. Validate the use of alternative data sources, such as Twitter and Google API, to assess and manage the needs of community members during heat and other climate emergencies.
7. Develop proactive outreach and mitigation strategies for cooling resources in the hottest communities of the city (most notably the central San Fernando Valley), and prioritize and plan heat mitigation strategies for/with climate vulnerable populations.

CHAPTER 2
EXECUTIVE SUMMARY

Introduction

As extreme heat events become more frequent and intense, cities must adapt to protect the health and safety of their residents without limiting their mobility. Some of these residents include transit dependent riders that utilize public bus service as their primary mode of transportation within the city. The health and comfort of passengers waiting for transit could be highly affected as extreme heat events intensify.[1] In 2018, the U.S. Global Change Research Program found that heat-related exposures of walking to and waiting for transit vary across neighborhoods in the City of Los Angeles based on local temperatures, transit service frequency, and the design of the street network.[2] Cities responded by increasing shade cover at bus stops because it can provide a high-impact way to improve the thermal comfort of transit riders.[3][4] This can be quite effective if done well; research on the increase of shade availability at bus stops demonstrated a reduction in the physiological equivalent temperature (PET) of up to 19°F.[5]

Despite bus shelters being essential public infrastructure for outdoor heat protection in Los Angeles, a recent study by UCLA Luskin School colleagues found that only 26% of bus stops operated by the Los Angeles County Metropolitan Transportation

1 USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

2 Fraser, Andrew M., and Mikhail V. Chester. "Transit System Design and Vulnerability of Riders to Heat." Journal of Transport & Health, vol. 4, 2017, pp. 216–25, https://doi.org/10.1016/j.jth.2016.07.005.

3 USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

4 Lanza, Kevin, and Casey P. Durand. 2021. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." International Journal of Environmental Research and Public Health 18(2): 463.

5 ibid

Authority (METRO) currently have shelters.[6] Los Angeles is not alone in under-providing shelters; cities rarely if ever provide full bus stop shelter coverage. Part of this is due to a coordination problem: the City, not transit operators, decides where to place bus shelters, and land use restrictions complicate siting. Planning for the efficient and equitable allocation of bus shelters in Los Angeles is complex and multifaceted, but it is also a promising opportunity to provide heat relief for the City's vulnerable transit riders.

Motivation

The previous contract between the City of Los Angeles Bureau of Streets Services, colloquially known as StreetsLA, and JCDecaux fell short of its aim in providing new bus stop shelters across Los Angeles due to a complex approval process which hindered implementation.[7] This contract was recently replaced by the new Sidewalk and Transit Amenities Program (S.T.A.P.) stemming from StreetsLA's new contract with Tranzito/Vector LLC (Tranzito) which may last up to 20 years. The ambitious program aims to include heat adaptation in its allocation strategy for bus stop shelter placements and to ensure that 75% of bus riders in each City Council District will have access to a bus shelter.

In this chapter, our research answers the question: Based on current evidence, does the City of Los Angeles' S.T.A.P. program appear to adequately and equitably provide extreme heat adaptation for transit riders? Our case study includes two types of analysis:

1. Qualitative analysis: A cross-city comparison of how other cities are combining bus shelter plans and extreme heat adaptation strategies. Bus stop field visits observing the current conditions of the bus stops in three focus council districts. Lastly, an analysis of the initial S.T.A.P contract functioning listing the advantages and disadvantages of a Public-Private Partnership (PPP) model for public infrastructure contracts was conducted.

6 Madeline Brozen, Chase Engelhardt, Eli Lipmen, . "Do LA Bus Riders Have Shelter from the Elements?" ArcGIS StoryMaps, February 17, 2023. https://storymaps.arcgis.com/stories/cf668947b-f424ae886edc89f2004fbd6.

7 Lance Oishi and Paul Gomez, Conversation on S.T.A.P. Contract with Streets LA. (2023).

2. Quantitative analysis: Compares the current state of bus shelter availability with mid-century heat projections in three in Los Angeles City Council Districts districts. We then select three council districts (3, 5, & 14) to serve as case studies to evaluate their local environmental and physical vulnerabilities. Our selected council districts represent a range of projected maximum temperatures, bus shelter availability, and socioeconomic demographics to ensure a broad representation of Los Angeles' diversity. Finally, we compare similarities and differences among the three council districts using 7 unique variables to evaluate the equity of the first-year S.T.A.P shelter allocations.

Findings

First, we find that the current version of the S.T.A.P program is limited in its potential to adequately or equitably provide heat relief for Los Angeles' transit riders. This is caused in part by the cost recovery aspect of the public-private partnership (PPP) model bus shelter siting relies on. While citywide bus shelter placement policy is not based on a commitment to shelters as truly public infrastructure for all, based on our review of other cities, we find Los Angeles is not unique in this regard. Historically, and across urban areas globally, we find that bus shelter placement policy is predominantly guided by the revenue potential of shelter advertisements and is often accomplished through public-private partnerships for infrastructure. As in other cases, we find that the starting point for shelter investments in Los Angeles is predominantly guided by the revenue potential of shelter advertisements, followed by political considerations over geographic equity, and lastly by bus stop use.[8] We find a similar pattern by looking at S.T.A.P. shelter placement decisions in 3 districts. Council Districts like Council District 3 and Council District 14 with high shelter needs based on heat and transit use are receiving far fewer new bus shelters under the S.T.A.P. for the first year compared to Council District 5, which has the highest allocation and highest median household income.

8 Law, Philip, and Brian D. Taylor. 2001. "Shelter from the Storm: Optimizing Distribution of Bus Stop Shelters in Los Angeles." Transportation Research Record: Journal of the Transportation Research Board 1753(1): 79–85.

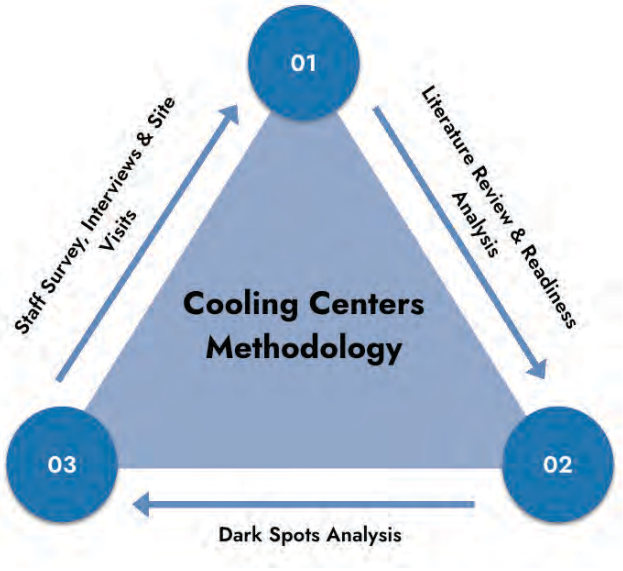
Recommendations

Based on our analysis, we recommend the following actions for the City of Los Angeles:

1. Reframing bus shelters as public infrastructure: Bus shelters should be recognized as essential public infrastructure and supported by a more robust public investment strategy.
2. Introduce a specific formula for bus stop allocation: Develop a clear and transparent methodology for siting bus shelters. This formula should consider factors such as existing equity and heat metrics to ensure equitable distribution of shelters across different neighborhoods.
3. Coordinate S.T.A.P. with other heat adaptation efforts: Improve coordination between S.T.A.P. and other heat adaptation initiatives in Los Angeles. This will ensure that bus shelter placements align with broader citywide strategies for mitigating the impacts of extreme heat.
4. Consider an alternative to the current heat metric in S.T.A.P. allocation criteria: One potential option is to incorporate Local Climate Zones (LCZs) as a heat metric, which can provide a more accurate assessment of local heat vulnerabilities and guide shelter placement decisions.
5. Engage residents and local stakeholders in designing and siting bus shelters: Involve residents and local stakeholders in the design and siting of bus shelters. Their input and feedback helps to ensure that shelters meet the needs of the community and are located in convenient and accessible locations.

It is important to note that our analysis takes place within the broader context of increased focus on bus shelters for heat adaptation in the City of Los Angeles. By embracing these recommendations and leveraging the city's unique position, Los Angeles has the opportunity to become a global leader in addressing heat-related challenges through innovative bus shelter policies. For further details, please refer to other chapters of this report and broader efforts by the City's Climate and Equity Mobilization Office (CEMO).

CHAPTER 3
EXECUTIVE SUMMARY



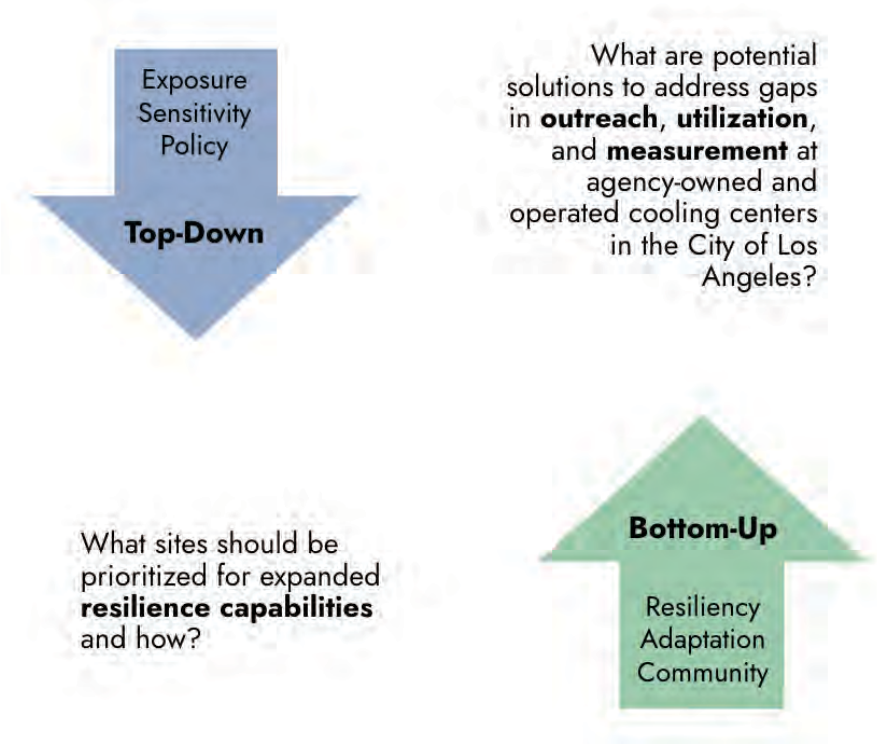
Extreme heat is the greatest climate threat facing Los Angeles today. According to the 2021 Los Angeles County Climate Vulnerability Assessment, it is estimated that by mid-century there will be a tenfold increase in the frequency, severity, and duration of extreme heat events. **As heat waves become more frequent and intense in Los Angeles, ensuring equitable access to cooling centers is imperative to protecting heat-vulnerable residents and communities who may otherwise lack access to cooling during a heat wave, particularly for unhoused residents and those without access to residential air conditioning.** With these increasing extreme heat events in Los Angeles, and based on the literature highlighting the effectiveness of cooling centers as an adaptation strategy for extreme heat events, there is a need for greater research on formal and informal cooling centers within the City of Los Angeles.[1] Cooling centers are sites open to the public that generally consist of an indoor, air-conditioned space to provide respite from the heat. Ready LA County defines augmented cooling centers as "sites that are operated by the County or City partners with days and/or hours of operation that differ from that site's standard hours of operation or are added

1 LA County Climate Vulnerability Assessment. (2021). LA County Chief Sustainability Office. https://ceo.lacounty.gov/wp-content/uploads/2021/10/LA-County-Climate-Vulnerability-Assessment-1.pdf

during specific heat events to expand Cooling Center services."[2] Cooling centers are an important adaptation strategy at a community level, because they provide accessible and free shelter to folks vulnerable to and suffering under extreme heat conditions. Cooling centers are especially necessary for folks who do not have air-conditioning in their homes, and can serve as a temporary intervention until all homes in Los Angeles are adequately cooled and weatherized against extreme weather conditions.

The main objective of this chapter is to explore the following research questions: *"What are potential solutions to address gaps in outreach, utilization, and measurement at agency-owned and operated cooling centers in the City of Los Angeles?"* and *"Which existing cooling center sites should be prioritized for expanded resilience capabilities and how?"* (Figure 1). Throughout our research, we are centering the vision statement of our partner, the Los Angeles Climate Emergency Mobilization Office (CEMO), which aims for, "Co-created, democratized, healthy, thriving, climate-resilient communities for all in the City of Angels."

Figure 1: Our research questions explore the ways in which we can combine top-down and bottom-up adaptive measures to address extreme heat across the City of Los Angeles



2 https://ready.lacounty.gov/heat/

This chapter encompasses a two-part analysis: 1) an analysis of existing cooling center conditions, capabilities, and readiness to determine how well current sites operate and are able to meet the needs of high-need communities, and 2) a Dark Spots Analysis to identify neighborhoods that are lacking in cooling center access and might be prioritized for new cooling center or community resilience centers in the future. We are applying a mixed methods approach to our analysis of cooling centers within the City of Los Angeles, drawing on extensive engagement with various City departments and stakeholders currently or prospectively involved in cooling center policy.

Our evaluation of current center operations relies primarily on qualitative data in the form of surveys, interviews, and site visits, as well as quantitative analysis on usage across existing sites. Results and findings are organized into five themes: 1) Outreach and Partnerships, 2) Physical Site Characteristics, 3) Accessibility and Demographics, 4) Programming and Site Services, and 5) Cooling Center Usage. The assessment of cooling center "Dark Spots," or areas of Los Angeles that are in need of cooling centers, primarily relies on quantitative data. We use various vulnerability indicators, past

#	Key Study Findings
1	City cooling centers see more visitors overall on extreme heat days, with notable increases in elderly and unhoused individuals as compared to other population groups
2	Air conditioning units may not work as well or break down during extreme heat days
3	Multilingual and targeted communications strategies are beneficial for conducting public outreach in diverse communities
4	Public safety is among the top concerns facing cooling center visitors and staff
5	Staff are interested and supportive of increased resiliency features and amenities at their sites
6	Unhoused communities require dignified cooling options that are accessible and tailored to their unique needs and experiences
7	A number of City-operated cooling centers are well-suited to become community resilience centers with increased funding for resiliency measures
8	Parts of the San Fernando Valley, East Los Angeles, South Los Angeles, and Harbor region exhibit high heat sensitivity and exposure that suggests an increased need for cooling center access

temperature data, future heat projections, and existing cooling center locations to locate neighborhoods that are in greatest need of these facilities. Below are the Key Findings from our research.

The collection and evaluation of both quantitative and qualitative data informs our final recommendations regarding gaps in existing cooling centers and the siting of new facilities. Through our qualitative and quantitative analysis of cooling centers across the City of Los Angeles, we have developed the following recommendations for CEMO and the City.

#	Key Study Recommendations
1	Expand beyond the traditional cooling center model toward a community resilience center model that supports climate-vulnerable communities
2	Expand access broadly to affordable and energy-efficient residential cooling for low-income and disadvantaged households
3	Develop relationships with unhoused communities and mutual aid organizations to co-develop heat responses that meet the needs of unhoused residents
4	Explore strategies to informally or semi-formally expand Los Angeles' cooling centers network to include various facility types
5	Prioritize new cooling and resilience center locations, existing center upgrades, and future activations in the South Valley, North Valley, and East Los Angeles
6	Streamline communications between City agencies, cooling center sites, and residents to optimize operations and increase community outreach
7	Invest in updating and expanding HVAC systems for existing cooling centers
8	Collect improved visitor data for existing cooling centers and bolster infrastructure and capabilities in facilities with higher rates of usage
9	Implement more individualized cooling solutions based on organization, site location, and needs of visitors

REPORT INTRODUCTION

Climate Change and Extreme Heat

Extreme heat events are expected to become more common, more severe and last longer in the future due to the acceleration of climate change.[1] Greenhouse gasses, such as carbon dioxide, methane, nitrous oxides, and water vapor, continue to accumulate in the atmosphere and "trap" heat near the Earth's surface. This will cause greater volatility and changes in weather patterns, including more frequent extreme heat events[2]

There are numerous ways to define both absolute and relative extreme heat. As one example, the U.S. Department of Homeland Security defines extreme heat events as a period of high heat (above 90°F) and humidity lasting for at least two or three consecutive days.[3] Both temperature and humidity are important metrics because both significantly impact how the body experiences heat. During times of extreme heat and humidity, the body expends more energy trying to cool off by sweating, a process that becomes increasingly difficult in high humidity.[4] Other factors that influence thermal comfort include the urban heat island effect, the albedo effect, vegetation, and shade.

Extreme heat has severe impacts on people. One of the main leading causes of weather-related morbidity across the globe is extreme heat, which only emphasizes the importance of heat relieving interventions.[5] Extreme heat is definitively the most dangerous weather-related hazard in the United States, causing more deaths than

1 Vaidyanathan, A., Malilay, J., Schramm, P., & Saha, S. (2020). Heat-related deaths — United States, 2004–2018. MMWR. Morbidity and Mortality Weekly Report, 69(24), 729–734. https://doi.org/10.15585/mmwr.mm6924a1

2 Shaftel, Holly, and Susan Callery. "FAQ: What Is the Greenhouse Effect?" NASA, NASA, https://climate.nasa.gov/faq/19/what-is-the-greenhouse-effect/#:~:text=Credit%3A%20NASA%20Jet%20Propulsion%20Laboratory,it%20would%20be%20without%20them.

3 "Extreme Heat." Extreme Heat | Ready.gov, Ready.gov, 1 Aug. 2022, https://www.ready.gov/heat#:~:text=Extreme%20heat%20is%20a%20period,which%20can%20lead%20to%20death.

4 Eidson, Millicent, and Stephanie Mack. (October 2016). "CLIMATE CHANGE and EXTREME HEAT What You Can Do to Prepare." Epa.gov, US Environmental Protection Agency & Center for Disease Control. https://www.epa.gov/sites/default/files/2016-10/documents/extreme-heat-guidebook.pdf.

5 ibid

hurricanes, floods, tornados, or extreme cold.[6] According to the Centers for Disease Control and Prevention (CDC), nearly 600 deaths are caused by extreme heat in the U.S. every year.[7] Moreover, as noted by the Los Angeles Times' investigative research on heat-related deaths in California, the actual number of heat-related deaths is likely to surpass official numbers.

Mechanisms of heat's impact on people are many but varied. The prolonged exposure to extreme heat can result in the onset of heat-related illnesses such as heat cramps, heat stroke and heat exhaustion, and can exacerbate preexisting chronic health conditions including respiratory and cardiovascular illnesses.[8] Prolonged exposure to high temperatures causes heat stress in the human body and could lead to elevated core body temperatures and serious health complications, especially when combined with high relative humidity. Signs of heat exhaustion include heavy sweating, muscle cramps, and fatigue. Symptoms of heat stroke, a potentially life-threatening condition, include headache, dizziness, nausea, confusion, fainting, and/or a body temperature of more than 103°F.[9]

Studies show that interventions need to be implemented, especially for vulnerable groups. Assessing where help is needed and then providing solutions in situ is the most effective. Extreme heat impacts physical and mental health, however, these impacts disproportionately affect people with preexisting health conditions, low-income populations, older adults, and infants and children.[10] [11]

Heat Risk in the City of Los Angeles

Extreme heat is the greatest climate threat facing the Los Angeles region today. Extreme heat is also a significant public health equity challenge for the City of Los

6 National Weather Service. (2022). Weather Related Fatality and Injury Statistics - 2021. NOAA. https://www.weather.gov/hazstat/

7 Centers for Disease Control and Prevention. (2023) "Natural Disasters and Severe Weather: Extreme Heat." Extreme Heat | Natural Disasters and Severe Weather | CDC.

8 Fraser, Andrew M., and Mikhail V. Chester. (2017). "Transit System Design and Vulnerability of Riders to Heat." Journal of Transport & Health 4: 216–25.

9 Centers for Disease Control and Prevention. (2023). "Heat Related Illness Warning Signs and Symptoms." https://www.cdc.gov/disasters/extremeheat/warning.html

10 DeShazo, J.R., et al. Adapting to Extreme Heat in California: Assessing Gaps in State-Level Policies and Funding Opportunities.

11 California Office of Environmental Health Hazard Assessment (OEHHA). 2019. Heat-related mortality and morbidity

Angeles in particular, which is home to 4 million people, or 40% of the County's population. The trend of increasing frequency and duration of heat events ("heat waves") is expected to continue to rise in the region and city specifically. The urban heat island effect (UHI), where a metropolitan area is significantly hotter than the surrounding regions, only exacerbates this issue in the City of Los Angeles.

Heat waves in Los Angeles have increased in intensity and duration in recent years, with more frequent and severe heat events only expected to grow in the coming decades. Rising temperatures and heatwaves are already directly affecting communities across Los Angeles. A historic, late-summer heat wave in 2020 set a new record high temperature for the city of Los Angeles, when the Woodland Hills neighborhood of the San Fernando Valley reached 121°F degrees on September 6, 2020.[12] An investigative report published by the Los Angeles Times in October 2021 found that emergency room visits rose nearly tenfold and overall deaths increased sharply in Los Angeles County during the September 2020 heat wave.[13]

Just in 2022, another historic heat wave hit Los Angeles and the majority of California when a "heat dome" descended upon the state from late August to early September. The extended heat wave was caused by an unusually strong high-pressure system that bore down on California to drastically intensify heat and offer no respite for nearly two weeks.[14] In the very near future, heatwaves like the Summer 2022 heat dome will increase in frequency and severity.

The Climate Emergency Mobility Office and Heat Equity Planning in LA City

A key part of the City of Los Angeles' recent planning and policy efforts to ensure climate, and more specifically– heat– equity are housed in the Climate Emergency Mobilization Office, which is unique across the U.S. The climate emergency and its dire impacts on frontline communities in the City of Los Angeles inspired the creation of the Climate Emergency Mobilization Office (CEMO) by January 2021, although the idea dates back to 2019. The office, guided by the principles of environmental justice,

12 Schwartz, M.S. (2020). "Record Heat Wave Creates 'Kiln-Like' Conditions In California." NPR. California Roasts As Record Heat Wave Exacerbates Devastating Fire Season" NPR.

13 Barboza, T., and Vives, R. (2021). "They really feel the heat; Poor communities bear the brunt of extreme temps, a legacy of 'racist decision-making'." Los Angeles Times.

14 Toohey, G. and Petri, A. (2022). "California heat waves are getting worse. Blame the vicious 'heat dome'." Los Angeles Times.

coordinates with the Mayor and City Council, and collaborates with City departments through meaningful engagement with frontline leaders and their communities. CEMO was launched to advance the goals of the City of Los Angeles' Green New Deal and increase collaboration with community leaders toward equitable climate solutions in frontline communities. The concept behind CEMO was developed by a group of local environmental justice organizations known as the Leap L.A. Coalition
CEMO is led by Director Marta Segura and housed within the Department of Public Works. In June 2022, Segura was also appointed as the City's first-ever Chief Heat Officer, responsible for developing a citywide Heat Action Plan to improve the City's communications and emergency response strategies to keep residents safe during extreme heat events.

With the establishment of CEMO and the Chief Heat Officer role, the City of Los Angeles is taking a holistic approach to addressing extreme heat and expanding measures to increase heat resilience and protection, particularly in frontline communities. Efforts are currently underway to improve the City's heat management systems that are essential to saving lives. In response to the 2022 Heat Dome event, CEMO developed the Cool Spots LA app to provide information on the City's augmented cooling centers, hydration stations, and public pools all in one comprehensive map.[15] In addition, CEMO partnered with the Liberty Hill Foundation to co-host the Climate Equity LA Series in 2022 and 2023, a workshop series designed to engage with community-based organizations and residents about how they experience climate inequities and extreme heat across the city.

UCLA Urban Planning Comprehensive Project with CEMO

CEMO has also begun broader work to identify and enact equitable strategies and policies to prevent, mitigate and undo impacts from past pollution and economic disinvestments and to ensure that frontline communities have a strong voice in policy and decision-making in the City of Los Angeles. This work has been done in partnership with many advocacy groups, students and scholars at UCLA including graduate-level Public Policy and Public Health students.

15 Cummens, P. (2022). "LA's New Chief Heat Officer Expands Cooling Centers Based on Equity Maps." ESRI. https://www.esri.com/about/newsroom/blog/los-angeles-chief-heat-officer-expands-cooling-centers/

Based on conversations between UCLA Urban Planning Professor Gregory Pierce, and Marta Segura, an agreement was reached for a "Comprehensive Project." Thirteen graduate-level Urban Planning students worked with CEMO on heat equity planning and strategies over the course of UCLA academic year 2022-2023. This report reflects their efforts and the results of that partnership.

The UCLA Urban Planning Comprehensive Project is a group project designed for Master of Urban and Regional Planning (MURP) students in their 2nd year in order to satisfy the capstone applied thesis requirement for their degree. These projects simulate real world planning practice in that they incorporate students from various areas of concentration working together to research a problem from multiple planning angles. This includes matching what is important to the public, government agencies and advocates with available data, both qualitative and quantitative, to aid in decision-making.

The scope of research for this Comprehensive Project was determined over a six month period from Spring to Fall 2022 between UCLA and CEMO based on a set of mutual interest, data availability, and analysis feasibility considerations. This project falls within the scope of the broader ongoing development of the City's Extreme Heat Plan and Framework. The aim of this study was to identify gaps in the City's intervention strategies that focus on populations most in need during extreme heat events: those who needed to make informational or emergency calls, bus transit riders, and those without indoor cooling access.

UCLA Comprehensive Project Report Structure

The structure of the remainder of the report is as follows. Each chapter contains an analysis representing one of the three intervention points of focus.

- **Chapter 1**: The Heat Emergency Data team conducts GIS mapping and data science analyses to understand hotspots and causes of heat vulnerability and health incidents in LA City to produce a full report and public presentation. This will help inform the city's early warning system and public health efforts, the use of UCLA Heat Risk Map, 311, and 911.

- **Chapter 2**: The Bus Shelter team analyzes the Sidewalk and Transit Amenities Program (S.T.A.P.) through qualitative and quantitative methods in the City of Los Angeles, focusing on the program's ability to provide heat relief for transit riders. This assessment helps highlight the limitations of the S.T.A.P. in providing heat relief equitably and inform the City's efforts in establishing a more transparent and inclusive allocation strategy for addressing heat-transit related challenges.

- **Chapter 3**: The Cooling Centers team analyzes the existing conditions and capabilities of two cooling center types: Los Angeles public libraries and select Recreation and Parks facilities. In addition, the team assesses City-wide vulnerability to determine which communities have the greatest need for cooling centers. These analyses will help CEMO apply for funding from the State of California to finance and build the capacity for additional cooling centers, reinforce and build the capacity of current facilities, and further strengthen the cooling center network by incorporating the Community Resilience Center model. The city-wide assessment of vulnerability will aid the office in determining where to locate such improvements.

SEEKING HELP DURING EXTREME HEAT EVENTS:

Can 311 and 911 Calls Inform Emergency Response Efforts in the City of Los Angeles?

Mariana Estrada
George Karam
Emma Ramirez
Tiffany Rivera
Seth Reichert

chapter 1

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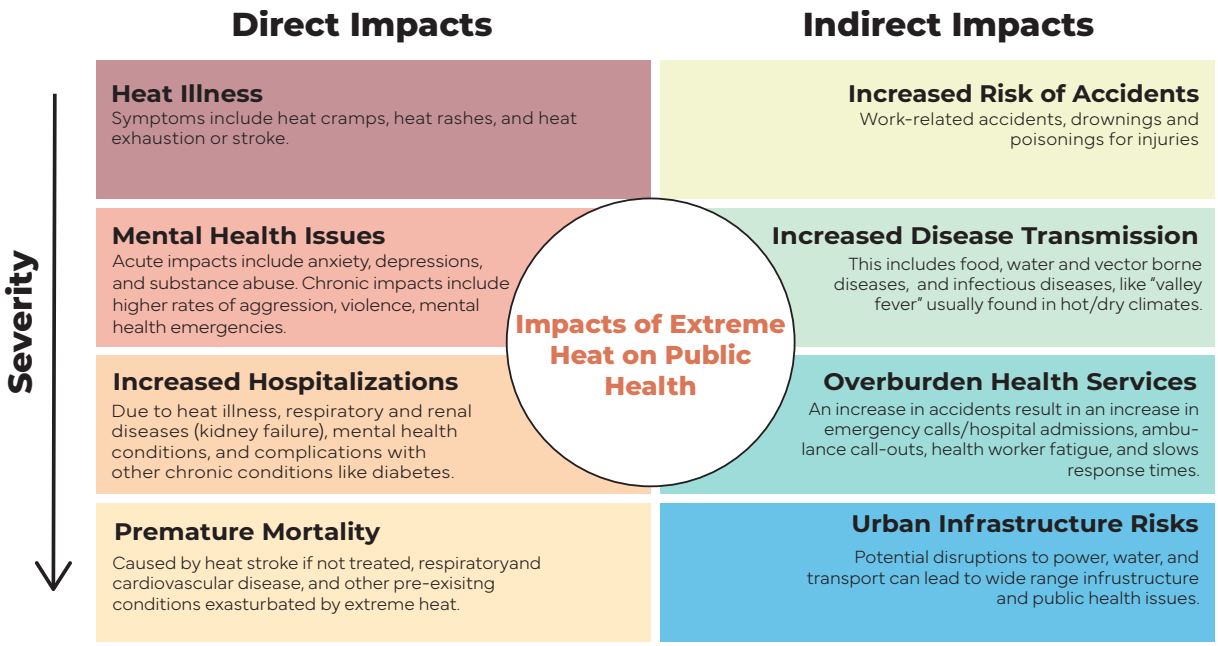
EXECUTIVE SUMMARY

Introduction

Climate change is expected to cause more frequent and severe extreme heat events — including in the Southern California region — catalyzing researchers to explore its potential impacts on public health and infrastructure. As extreme heat events become more common and severe across the globe, literature documenting the wide-ranging physical and mental health impacts continues to grow. In addition to adverse health impacts, elongated extreme heat events can have expansive indirect impacts as shown in Figure 1 below.

Figure 1: Direct and Indirect Impacts of Extreme Heat



Extreme heat events increasingly have a significant impact on public and mental health.[1][2] More broadly, these events can lead to indirect cascading effects that impact a variety of municipal and infrastructure services. For example, increased use of AC systems in residential and commercial buildings can strain power supplies, and create

1 Sorensen, C., & Hess, J. (2022). Treatment and Prevention of Heat-Related Illness. New England Journal of Medicine, 387(15), 1404–1413. https://doi.org/10.1056/NEJMcp2210623

2 Center for Disease and Control Prevention. (nd). Warning Signs and Symptoms of heat-Helated Illness. CDC. https://www.cdc.gov/disasters/extremeheat/warning.html

disruption in power distribution[3]. Understanding how the intersectionality of extreme heat mitigation, emergency response, and urban infrastructure systems directly impacts public health outcomes is critical when developing a heat action plan for the City Los Angeles, especially for the City's most vulnerable populations.

Past studies within municipalities in Canada and the United States have used the volume of heat-related emergency department (ED) visits and hospitalizations as indicators to measure the health impact of extreme heat exposure.[4] [5] Our analysis aims to support the Los Angeles City Climate Emergency Mobilization Office's (CEMO) request to explore the potential for using excess 911 and 311 calls as alternative or complementary indicators for determining residents' exposure and response to extreme heat events. More specifically, we ask whether or not 911 and 311 call volumes increase during periods of extreme heat. By comparing both systems' call data to identify past regional heat events and heat-vulnerable populations, the City of Los Angeles may better identify communities most exposed to the impacts of extreme heat or reveal gaps in current emergency management response.

For the purposes of this report, we use emergency health information from 911 call data and the City's individual non-emergency information request call data from 311 to create a novel and more holistic analysis of the public health impacts caused by heat events. The aim with this analysis is to explore the level of public engagement with 911 and 311 call services during extreme heat events within the past five years (2018-2022).

The analysis in this chapter attempts to answer the following questions: (1) Is there a correlation between daily maximum temperature (extreme heat events) and 911 or 311 call volumes? (2) Are there excess calls to 911 and 311 systems during extreme heat events? And (3) do excess call volumes inform the City of Los Angeles regarding areas most impacted by extreme heat, and thus in need of additional emergency resources? By identifying which communities are most impacted by extreme heat events through an analysis of excess emergency and non-emergency calls, we are able to

3 "CAISO Warns Excessive Heat Will Stress Power Grid." Energized by Edison, 18 May 2023, energized.edison.com/stories/caiso-warns-excessive-heat-will-stress-power-grid.

4 Dolney, Tim & Sheridan, Scott. (2006). The relationship between extreme heat and ambulance response calls for the city of Toronto, Ontario, Canada. Environmental research. 101. 94-103. 10.1016/j.envres.2005.08.008.

5 Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H. G., Smith, D., Solomon, G., Trent, R., & English, P. (2009). The 2006 California heat wave: impacts on hospitalizations and emergency department visits. Environmental health perspectives, 117(1), 61–67. https://doi.org/10.1289/ehp.11594

offer recommendations to the newly established CEMO and other LA City agencies that can guide how best to equitably distribute both emergency and non-emergency services.

Data and Methods

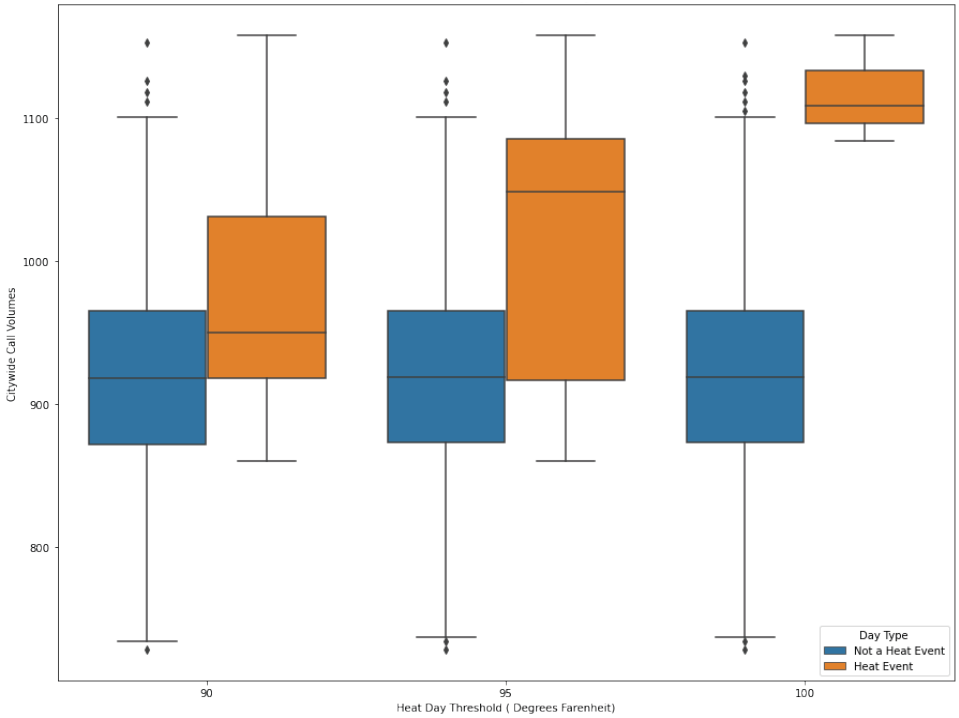
We explore novel data we obtained on 911 call volumes at the fire station district level (of which there are 102 in the city of Los Angeles) and 311 information request call volumes at the city level. These scales are reflective of the most granular data available upon request. For both analyses we constructed a daily high heat index for the relevant geography and assess whether more calls occurred during a "heat event", defined as the second or greater consecutive day of high heat (the second, third, fourth, or nth day in a row over a heat threshold). This definition of a heat event ensures our analysis is sensitive to air temperature, humidity, and the impacts of extended periods of heat. We test three temperature thresholds to define these periods of high heat: 90°F, 95°F, and 100°F. We define excess calls as the number of calls that occurred on heat days in a given fire district that were greater than one standard deviation above the average number of calls in that district on non-heat days.

To better understand the communities living in the fire districts with the highest excess call volumes, we explore this alongside vulnerability data for the seven fire districts with the highest excess calls using the Los Angeles County Climate Vulnerability Assessment and compare them to the fire districts with the lowest excess calls.

Findings

We find a statistically significant correlation between 911 call volumes and daily maximum temperature across the city. This relationship holds true for 911 call volumes across the city as a whole when defining heat events as the second or greater consecutive day of heat exceeding each of the 90°F, 95°F, and 100°F thresholds tested (See Figure 2).

Figure 2: Call Volume Distribution by Heat Threshold

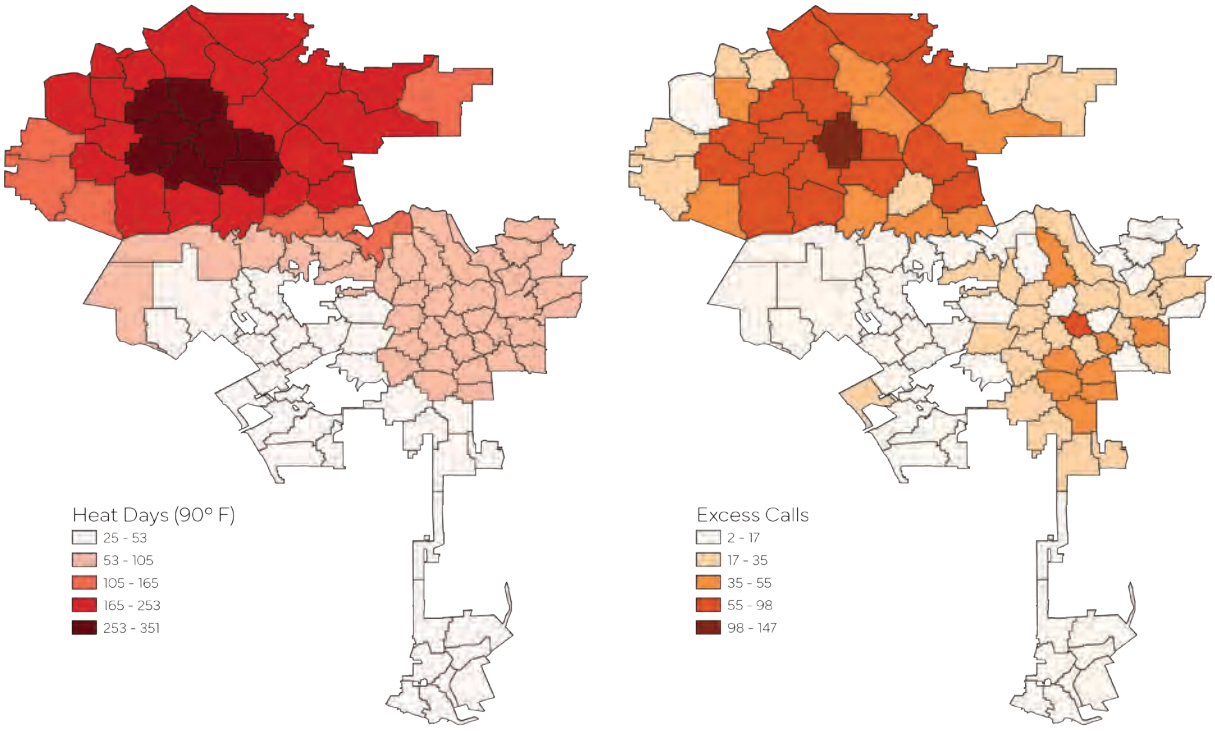


For 311 call volumes and heat, we do not find a definitive relationship. Initial regression analysis does not show an immediate relationship; however, when performing a one-sided t-test, we find that there are statistically significant greater average 311 call volumes on heat days and events over 90°F than on non-heat days.

We then use 90°F (a commonly used threshold) as the heat threshold to determine the number of excess calls due to heat. We estimate that there were approximately 3,291 excess calls due to heat in the City of Los Angeles between 2018 and 2022 when compared to the baseline of one standard deviation above the average daily call volumes in each fire station district. The distribution of call volumes across the city, shown in Figure 3, appears to manifest in a related but not parallel pattern to the number of heat days themselves.

Quantitatively, climate-vulnerability did inform the number of excess calls in addition to extreme heat. The fire districts with the highest excess call volumes during days that were 90°F or above had larger climate-vulnerable populations including children, older adults, and older adults living alone — as well as higher rates of asthma,

Figure 3: Excess 911 Calls in LA City, 2018-2022



cardiovascular disease, and disability. These fire districts also had larger percentages of renters, those rent burdened, those with no health insurance, and those living in poverty, while fire districts with the least excess calls housed smaller percentages of climate-vulnerable populations.

Recommendations

Based on these results, our main recommendations for CEMO, the city as a whole, the 911 response team (including LAFD, LAPD, and EMD), and the 311 (ITA) response system given their roles as collaborators in developing a Heat Action Plan and delivering essential city services to residents are:

1. Consider the practical implementation steps for use of 911, and potentially 311, call data volumes as heat emergency indicators alongside existing metrics.
2. Collect additional datasets to control for confounding variables (such as events, employment, demographics, and land uses) that can affect 911 and 311 call

volumes during extreme heat events.

3. Develop clear data collection and reporting procedures for both 311 and 911 call centers to ensure that all data contains geographic information for future analysis.
4. Aggregate 911 calls to city council districts based upon the locations of fire stations to apply recommendations to political boundaries in addition to administrative boundaries.
5. Create more expansive definitions of Heat Advisory and Heat Alert that use lower heat thresholds (90°) than existing city and county policy (95°F in the LA Basin and 100°F in the Valleys) in order to activate additional services.
6. Validate the use of alternative data sources, such as Twitter and Google API, to assess and manage the needs of community members during heat and other climate emergencies.
7. Develop proactive outreach and mitigation strategies for cooling resources in the hottest communities of the city (most notably the central San Fernando Valley), and prioritize and plan heat mitigation strategies for/with climate vulnerable populations.

INTRODUCTION

Climate change is expected to cause more frequent and severe extreme heat events — including in the Southern California region — catalyzing researchers to explore the potential impacts on public health and infrastructure. As a result, many cities have been using rates of morbidity and mortality as indicators to measure the health impact of extreme heat exposure. Previous public health studies have demonstrated the relationships between heat-related mortality and air temperature while others have established a link between emergency department visits (EDV) and heat events.[6] Although the relationships between heat and EDV, and heat and morbidity has been clearly established, a uniform definition on how to define extreme heat has not. For example, Davis and Novicoff define extreme heat events as a period of 3 or more consecutive days with a threshold of 95°F.[7] Another study conducted by the Centers for Disease Control and Prevention defined an extreme heat event as a period with two or more consecutive days with a threshold of 95°F.[8] This discrepancy begs the question for how cities should define "extreme heat events." Furthermore, are heat thresholds currently set at the appropriate level to prevent avoidable public health issues such as heat-related hospitalizations?

In Canada and the United States, several municipalities have used emergency (911) and non-emergency (311) call data as a means to explore these questions and community response to extreme heat.[9] The City of Los Angeles is no different. In preparation for establishing the City's Extreme Heat Action Plan, the City of Los Angeles Climate Emergency Mobilization Office (CEMO) has identified three critical intervention points (cooling centers, bus shelters, and emergency/non-emergency call data) needing deeper investigation. As a part of this study by UCLA Urban Planning Masters Students, we are investigating for CEMO how 911 and 311 call volumes during extreme

6 Wald, A. "Emergency Department Visits and Costs for Heat-Related Illness Due to Extreme Heat or Heat Waves in the United States: An Integrated Review." Environmental Health Perspectives, vol. 126, no. 5, 2018, pp. 1-12, doi:10.1289/EHP3546.

7 Davis, R.E., & Novicoff, W.M. (2018). The impact of heat waves on emergency department admissions in Charlottesville, Virginia, U.S.A. International Journal of Environmental Research and Public Health, 15(1436). doi:10.3390/ijerph15071436

8 Centers for Disease Control and Prevention (CDC). (2013). Heat illness and deaths – New York City, 200-2011. MMWR, 62(31), 617-621.

9 Kianmehr, A., & Pamukcu, D. (2021). Analyzing citizens' needs during an extreme heat event, based on 311 service requests: A case study of the 2021 heatwave in Vancouver, British Columbia.

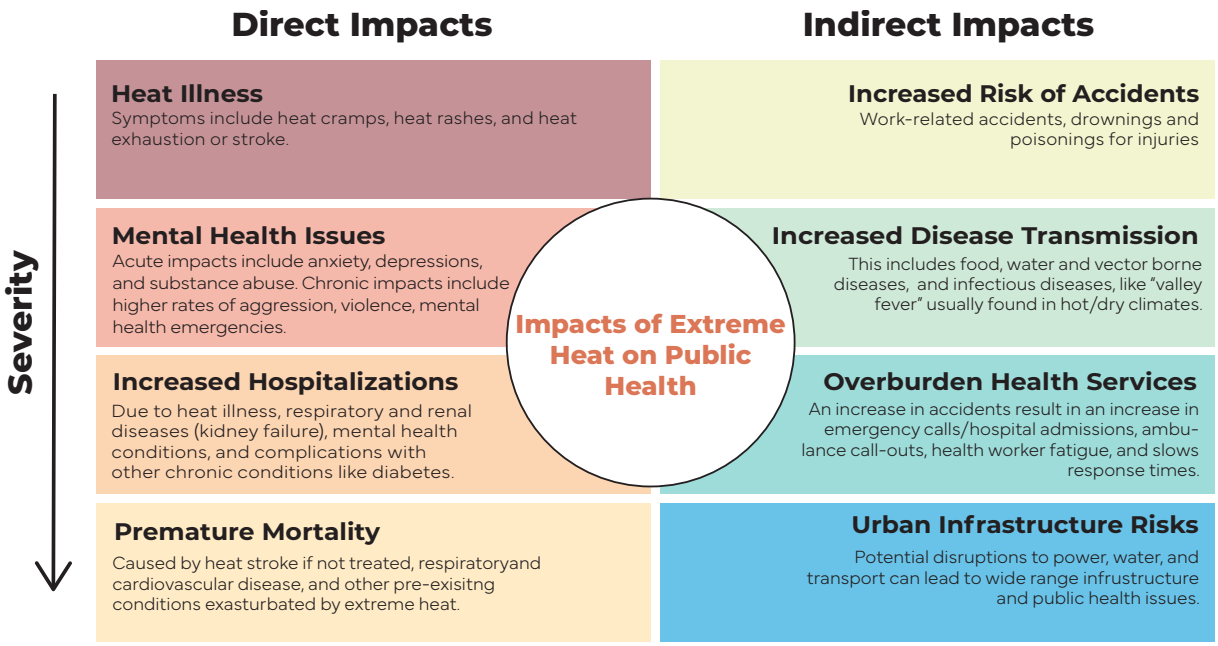
heat vs non-extreme heat days can help the City identify the location and needs of communities most impacted during extreme heat events. The goal of this effort is to identify gaps in current mitigation and emergency management interventions for extreme heat and recommend equitable strategies which the City can apply in the future Extreme Heat Action Plan.

In this chapter, we examine three research questions: (1) *Is there a correlation between daily maximum temperature (extreme heat events) and 911 or 311 call volumes?* (2) *Are there excess calls to 911 and 311 systems during extreme heat events?* and (3) *do excess call volumes inform the City of Los Angeles regarding areas most impacted by extreme heat, and thus in need of additional emergency resources?*

Heat and Systems: Impacts of Extreme Heat on Infrastructure and Health

At a broad geographic scale, many of the heat-related impacts mentioned in the introductory chapter of this report are interconnected in ways that can lead to indirect cascading effects of increasing severity. In addition to public health implications,

Figure 4: Direct and Indirect Impacts of Extreme Heat



extreme heat events can also impact a variety of municipal and infrastructure services, as highlighted in Figure 4. For example, broad indirect impacts associated with extended periods of extreme heat include an increase in food, water and vector-borne diseases.[10] In urban areas, continuous extreme heat events put additional strain on important emergency medical services including paramedic response, transportation, and emergency room care. As periods of high temperature continue to become more severe, barring considerable public intervention, an increase in heat-related illnesses and deaths will become more common. This, in turn, can increase the number of hospital calls and emergency room visits, inundating health care responders and other medical services, resulting in slower response and treatment times for those most at risk for heat-related ailments.

In the context of urban infrastructure, longer and more extreme heat events also make older critical infrastructure systems—including water, power, and transportation systems—more vulnerable to the compounding impacts of extreme heat.[11] Thus, examining the intersectional effects of extreme heat mitigation, emergency response, and urban infrastructure systems on public health outcomes is key to developing a heat action plan for the City of Los Angeles, prioritizing the city's most vulnerable populations.

Managing the adverse impacts of extreme heat needs to occur simultaneously with actions to increase a city's adaptive capacity to mitigate risks before, during, and after any disaster. Common strategies essential to reducing vulnerability when preparing, mitigating and/or responding to extreme weather events include adaptive measures, effective warning and accurate weather systems, identifying vulnerable communities, having government support, establishing emergency action plans, and using place-based planning.[12] [13] [14] [15] However, as climate disasters become increasingly more

10 SCAG. (2020 September). Extreme Heat & Public Health Report. Southern California Association of Governments.https://scag.ca.gov/sites/main/files/file-attachments/extremeheatpublichealthreportfinal_09302020.pdf?1634674354

11 Clark, S. S., Chester, M. V., Seager, T. P., & Eisenberg, D. A. (2019). The vulnerability of interdependent urban infrastructure systems to climate change: Could Phoenix

12 Cutter, S. L., Barnes, L., Berry, M., Burton, C., Evans, E., Tate, E., & Webb, J. (2008). A place-based model for understanding community resilience to natural disasters. Global Environmental Change, 18(4), 598–606. https://doi.org/10.1016/j.gloenvcha.2008.07.013

13 Godschalk, D. R. (2003). Urban Hazard Mitigation: Creating Resilient Cities. Natural Hazards Review, 4(3), 136–143. https://doi.org/10.1061/(ASCE)1527-6988(2003)4:3(136)

14 Menoni, S., Molinari, D., Parker, D., Ballio, F., & Tapsell, S. (2012). Assessing multifaceted vulnerability and resilience in order to design risk-mitigation strategies. Natural Hazards, 64(3), 2057–2082. https://doi.org/10.1007/s11069-012-0134-4

15 Wilhelmi, O. V., & Hayden, M. H. (2010). Connecting people and place: a new framework for

common and volatile, so do the adverse public health impacts, forcing us to rethink our strategies for emergency response and preparedness.

To this point, researchers are increasingly analyzing the interaction between people and social media and/or city service platforms as a tool to better understand how users respond to and during extreme weather events.[16] [17] [18] Local 911 and 311 systems are starting to be used more frequently due to the detailed spatial and temporal information that can be inferred in both past and present needs of vulnerable residents.[19] Furthermore, as people continue to use their cellphones and other digital devices as their main source for information, cities can better use alternative platforms like social media as a tool for mitigation and management during times of disaster.

For the purposes of this report, we call data from the City of Los Angeles' 911 system (a novel dataset) and 311 information requests to create an analysis of the larger public health emergencies, exploring beyond heat-related emergency department visits (EDV), hospitalizations, and death. The aim of this analysis is to explore the relationship between 911 and 311 calls and extreme heat events by analyzing call volumes over the past five years (2018-2022). Another goal in this exploratory research is to assess the distributive impacts of extreme heat events across the City of Los Angeles, including the number of heat events per year and average excess 911 and 311 calls, to support CEMO's efforts in developing a Heat Action Plan. This chapter explores emergency (911) and non-emergency (311) call data in relation to heat in the City of LA in an attempt to answer the following questions:

1. Is there an increase in the volume of calls for 911 and 311 systems during extreme heat events?

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reducing urban vulnerability to extreme heat. Environmental Research Letters, 5(1), 014021. https://doi.org/10.1088/1748-9326/5/1/014021

16 Wu, W.-N. (2021). Does Citizens' 311 System Use Improve Satisfaction with Public Service Encounters?—Lessons for Citizen Relationship Management. International Journal of Public Administration, 44(8), 665–673. https://doi.org/10.1080/01900692.2020.1744644

17 Berglez, P., & Al-Saqaf, W. (2021). Extreme weather and climate change: social media results, 2008–2017. Environmental Hazards, 20(4), 382–399. https://doi.org/10.1080/17477891.2020.1829532

18 Zander, K. K., Rieskamp, J., Mirbabaie, M., Alazab, M., & Nguyen, D. (2023). Responses to heat waves: what can Twitter data tell us? Natural Hazards, 116(3), 3547–3564. https://doi.org/10.1007/s11069-023-05824-2

19 Kianmehr, A., & Pamukcu, D. (2021). Analyzing citizens' needs during an extreme heat event, based on 311 service requests: A case study of the 2021 heatwave in Vancouver, British Columbia.

2. If so, in which areas of Los Angeles are these additional calls coming from?
3. How can the distribution of calls inform CEMO's heat action plan, and the City's broader heat response activities and evaluation system?

Before moving forward, we note that understanding heat events only as an "emergency" and not also as symptomatic of chronic systemic issues (such as energy poverty) does not allow for sufficient nuance in developing mitigation and adaptation strategies. As such, our recommendations aim to address extreme heat both as an emergency as well as a chronic stressor for residents within the City of Los Angeles.

The remainder of this chapter is structured as follows: First, we discuss the public health inequities associated with extreme heat that influenced our motivation to conduct this research. Second, we will provide background context and research associated with public emergency preparedness systems and corresponding agencies that provide these services within the City of Los Angeles. Third, we will explain our research data and methods, breaking down our analytical process into four steps. Fourth, we review our findings regarding the volume and distribution of calls for both 911 and 311 data, examining any geospatial parallels with established heat vulnerable populations. Fifth, we discuss the significance and limitations of our preliminary results. Finally, we conclude the chapter with a list of recommendations for CEMO based on both our qualitative and quantitative research.

MOTIVATION

Urban Heat and Public Health

Excessive heat exposure compromises the body's ability to thermoregulate.[20] When combined with particulate air pollution, extreme heat events increase the risk for a variety of direct and acute health impacts including heat-related illnesses, induced cardiorespiratory diseases, and premature death.[21] In addition to acute impacts from extreme heat, long-term exposure can exacerbate other underlying health issues like diabetes, cardiovascular disease, and asthma while inducing new ailments like renal (kidney) disease.[22]

With an increase in public health impacts due to extreme heat, quantifying the association between extreme heat events and health service response has been difficult to measure. Past studies in California have documented an increase in emergency department visits for heat-related causes during extreme heat events.[23] Furthermore, in 2022, a team of researchers from USC found that on days with extreme heat and air pollution, deaths were 21% more likely.[24] These events have dire, yet overlooked, consequences. A study by the LA Times in October of 2021 reported that during the hottest decade on record (between 2010-2019), California's official data from death certificates attributed 599 deaths to heat exposure while their analysis indicated an actual value six times higher.[25]

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20 Rahman, M. M., McConnell, R., Schlaerth, H., Ko, J., Silva, S., Lurmann, F. W., Palinkas, L., Johnston, J., Hurlburt, M., Yin, H., Ban-Weiss, G., & Garcia, E. (2022). The Effects of Coexposure to Extremes of Heat and Particulate Air Pollution on Mortality in California: Implications for Climate Change. American Journal of Respiratory and Critical Care Medicine, 206(9), 1117–1127. https://doi.org/10.1164/rccm.202204-0657OC

21 ibid

22 CDC. (2020, April 15). Warning Signs and Symptoms of Heat-Related Illness | Natural Disasters and Severe Weather | CDC. https://www.cdc.gov/disasters/extremeheat/warning.html

23 Knowlton, K., Rotkin-Ellman, M., King, G., Margolis, H.G., Smith,D., Solomon, G., Trent, R., and English, P.. (2009). The 2006 California Heat Wave: Impacts on Hospitalizations and Emergency Department Visits. Environmental Health Perspectives 117:1. https://doi.org/10.1289/ehp.11594

24 Rahman, M. M., McConnell, R., Schlaerth, H., Ko, J., Silva, S., Lurmann, F. W., Palinkas, L., Johnston, J., Hurlburt, M., Yin, H., Ban-Weiss, G., & Garcia, E. (2022). The Effects of Coexposure to Extremes of Heat and Particulate Air Pollution on Mortality in California: Implications for Climate Change. American Journal of Respiratory and Critical Care Medicine, 206(9), 1117–1127. https://doi.org/10.1164/rccm.202204-0657OC

25 Phillips, A.M., Barboza, T., Vives, R., Greene, S.,. (2021 October 7). Extreme heat is one of the deadliest consequences of climate change. Los Angeles Times. https://www.latimes.com/projects/california-extreme-heat-deaths-show-climate-change-risks/

Health symptoms and responses associated with extreme heat morbidity and mortality have been harder to quantify than heat-related emergency department visits. Symptoms of heat stress include headache, nausea, dizziness, irritability and heavy sweating–all symptoms associated with a variety of ailments.[26] Additionally, lack of education in identifying heat-related illnesses including heat rashes, heat cramps, heat exhaustion, heat stroke and heart attacks may also contribute to undercounting of heat related illnesses and deaths.[27] In addition to physical impacts, excessive exposure to extreme heat also contributes to an increase in mental health issues. A 2017 report from the American Psychological Association found that major acute mental health impacts of climate change included anxiety, compound stress, substance abuse and depression while major chronic mental health impacts include higher rates of aggression and violence and an increase in mental health emergencies[28]. Additionally, more recent studies have shown that high temperatures can impair academic performance and cognitive skill development in children at school.[29]

Climate Vulnerable Populations and Heat (In)-Equity

Extreme heat affects Angelenos' physical and mental health; however, these impacts disproportionately affect those with preexisting health conditions, low-income populations, older adults, and infants and children.[30] These groups are identified as climate-vulnerable largely as a result of being unable to thermoregulate efficiently, resulting in high sensitivity to extreme heat during prolonged exposure to high temperatures with limited to no agency to access cooler temperatures.[31] Consequently, they may be more likely to need emergency services if they don't have adequate resources to cool down during extreme heat events.[32]

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26 Center for Disease and Control Prevention. (nd). Warning Signs and Symptoms of heat-Helated Illness. CDC. https://www.cdc.gov/disasters/extremeheat/warning.html

27 Sorensen, C., & Hess, J. (2022). Treatment and Prevention of Heat-Related Illness. New England Journal of Medicine, 387(15), 1404–1413. https://doi.org/10.1056/NEJMcp2210623

28 Clayton, S., Manning, C. M., Krygsman, K., & Speiser, M. (2017). Mental Health and Our Changing Climate: Impacts, Implications, and Guidance. Washington, D.C.. American Psychological Association and ecoAmerica. https://doi.org/10.1037/e503122017-001

29 Park, R. J., Goodman, J., Hurwitz, M., & Smith, J. (2020). Heat and learning. American Economic Journal: Economic Policy, 12(2), 306-39.

30 DeShazo, J.R., et al. Adapting to Extreme Heat in California: Assessing Gaps in State-Level Policies and Funding Opportunities.

31 ibid

32 "Climate Change and the Health of Socially Vulnerable People." EPA, www.epa.gov/climateim-

People with preexisting conditions such as asthma and cardiovascular disease are particularly vulnerable to extreme heat events. Due to their illness, high temperatures can cause the narrowing of airways which make breathing difficult and can trigger asthma attacks.[33] Extreme heat also worsens air quality by increasing ozone pollution and particulate pollution which also heightens asthma symptoms. Additionally, according to a multinational study, death rates of cardiovascular disease, which is the leading cause of death in the world, was associated with extreme heat temperatures.[34] People with other preexisting conditions are also sensitive to extreme heat since they may be taking medication that makes them more sensitive to heat or they may not be able to take the proper measures to access cooler temperatures due to physical disability.[35]

Several sub-populations are also sensitive to the effects of extreme heat based on their age. Older adults are among the most impacted by extreme heat, especially those living in assisted living facilities, confined to a bed, or living alone.[36] Elderly people are also less able to identify extreme temperatures and may have preexisting conditions that make them more susceptible to heat-related illnesses. They may also have limited mobility which can also impact their ability to respond to heat.[37] Additionally, infants and young children are more prone to dehydration and extreme heat illness since they have a smaller body mass to surface area ratio and have undeveloped respiratory systems.[38] They are also more heat-vulnerable due to behavioral characteristics, such as, spending a large amount of their time in outdoor playgrounds and not being able to make adjustments such as accessing air-conditioning, shade, and water.

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pacts/climate-change-and-health-socially-vulnerable-people. Accessed 17 May 2023.

33 "Summer Asthma and Warm Weather." Allergy & Asthma Network, https://allergyasthmanetwork.org/news/summer-asthma-and-warm-weather/#:~:text=Hot%20weather%20aggravates%20asthma.,the%20risk%20of%20air%20pollution.

34 Associations between Extreme Temperatures and Cardiovascular Cause ... https://www.ahajournals.org/doi/10.1161/CIRCULATIONAHA.122.061832.

35 "Heat and People with Chronic Medical Conditions." Centers for Disease Control and Prevention, Centers for Disease Control and Prevention, 19 June 2017, https://www.cdc.gov/disasters/extremeheat/medical.html.

36 Kenny, Glen P, et al. "Heat Stress in Older Individuals and Patients with Common Chronic Diseases." CMAJ : Canadian Medical Association Journal = Journal De L'Association Medicale Canadienne, U.S. National Library of Medicine, 13 July 2010, https://www.ncbi.nlm.nih.gov/pmc/articles/PMC2900329/.

37 ibid

38 "Protecting Children's Health During and After Natural Disasters: Extreme Heat." EPA, Environmental Protection Agency, https://www.epa.gov/children/protecting-childrens-health-during-and-after-natural-disasters-extreme-heat#:~:text=Why%20are%20children%20more%20susceptible,-can%20lose%20more%20fluid%20quickly.

Another climate-vulnerable demographic includes low-income and socially-marginalized individuals, including the unhoused, both because of the mediating factor of the built environment they live in (or lack thereof) and their ability to cool it. In California, approximately 60% of housing units were built before 1979, which often means lower thermal performance.[39] This is particularly concerning for low-income populations since they are more likely to own or rent older homes and those renting don't have control over thermal performance investments in the property.[40] Additionally, low-income populations may be forced to choose between cooling their homes or paying for other necessities such as food due to affordability constraints.[41] In Southern California, with every day that exceeds 95°F, electricity expenses go up 1.6% in a pay period.[42] Additionally, the risk of electricity disconnection increases 1.2% between 51-75 days later. It is also projected for disconnections to increase to 12% under a "worst case" emissions scenario (representative concentration pathways 8.5, or "RCP" 8.5 scenario) by the end of the century. As heat events become more common, the effects will likely continue to be felt most strongly by socially marginalized and low income groups.

39 DeShazo, J.R., et al. Adapting to Extreme Heat in California: Assessing Gaps in State-Level Policies and Funding Opportunities.

40 ibid

41 ibid

42 Barreca, A., Park, R.J. & Stainier, P. High temperatures and electricity disconnections for low-income homes in California. Nat Energy 7, 1052–1064 (2022). https://doi.org/10.1038/s41560-022-01134-2

EMERGENCY SYSTEMS BACKGROUND

Public Emergency Preparedness Systems

Municipal services, such as cooling centers, can provide a line of defense for these climate vulnerable populations, but emergency services can provide a last backstop for those already facing the health impacts of heat.

For most people, their primary connection to municipal emergency systems is dialing 911 during extraordinary circumstances. This emergency response system was first implemented in the 1960s and quickly deployed across the country. This system was designed to be an accessible means for individuals to connect with emergency services no matter where in the country one might be, and it has been incredibly successful in this mission.

First responder systems and emergency preparedness structures in any given area are often deeply complex. They typically require coordinated efforts not only between agencies such as police, fire, and health departments but also among these respective departments across jurisdictions (between individual cities, counties, and state levels). When someone calls 911, they are directed to a public safety answer point (PSAP) where their call is processed and the necessary first responders are dispatched. In the City of Los Angeles, there are currently 21 PSAPs operated by a number of different agencies, such as fire, police, and sheriff departments.[43] As such, unpacking the structure of emergency response systems is quite complicated.

Key Response and Prevention Units Within the City of Los Angeles

Below we highlight the key agencies and services associated within the scope of our research. For the purpose of this chapter, we identify three typologies of emergency management: *Emergency Services, Non-emergency Services, and Early Warning*

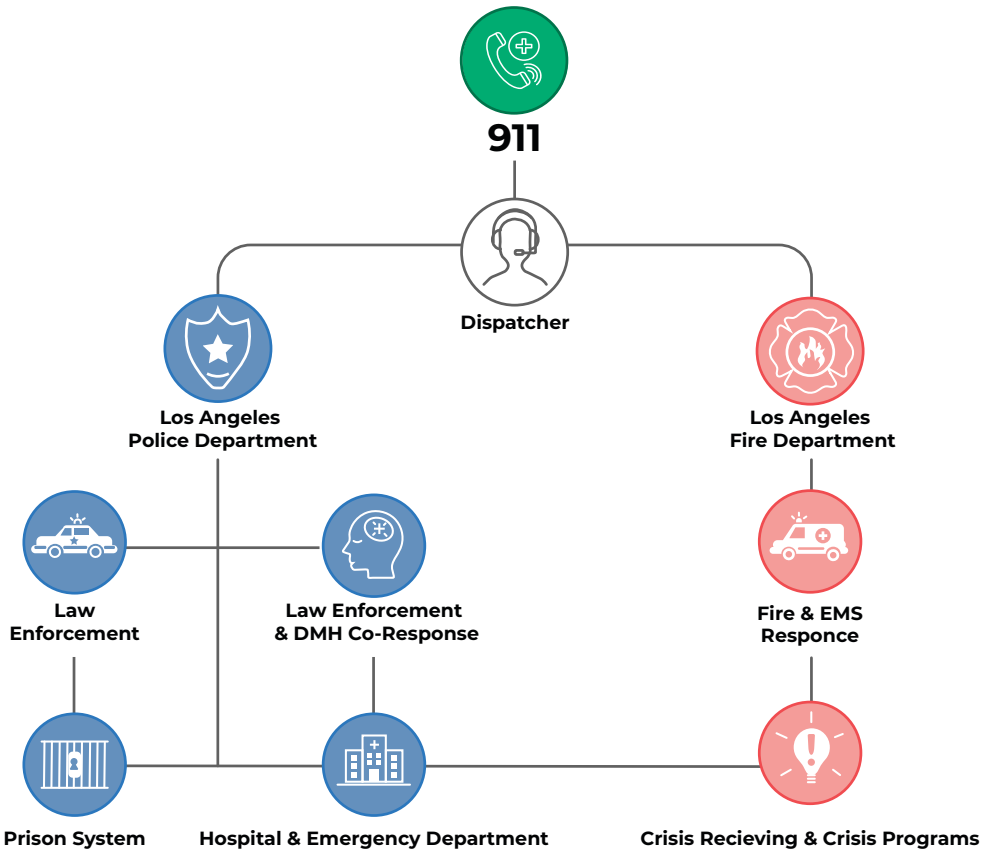
43 911 Master PSAP Registry. (n.d.). Retrieved May 8, 2023, from https://www.fcc.gov/general/9-1-1-master-psap-registry

Response. All City entities included in this chapter are organized into these categories based on what stage their services are applied. Although the main focus of our research is on analyzing volumes of resident calls associated with emergency (911) and non-emergency (311) services, it is important to understand how the entities associated with Early Warning Response are also connected to other city services, especially during extreme heat events.

In exploring the landscape of key agents for non-emergency and emergency response, we answer the following questions:

- What jurisdictions/agencies/departments/bureaus are involved?
- Who responds, and at what stage?
- What critiques or gaps are found in scholarly literature or when speaking with agency representatives regarding the responsiveness of these services?
- How can the findings from this analysis inform CEMO's heat action plan, resource allocation, and coordination between city services?

Figure 5: 911 Processes in the City of Los Angeles



Emergency Services - 911 (Los Angeles Fire Department and Police Department)

A separate agency, LA City Metropolitan Fire Communications (MFC), is responsible for processing 911 and non-emergency fire department calls and dispatches Los Angeles Fire Department (LAFD) resources. MFC works with the Los Angeles Police Department (LAPD), the Los Angeles County Fire Department (LACOFD), and the Los Angeles County Sheriff's Department (LASD) to coordinate emergency responses throughout Los Angeles City. Additionally, the Communications Division of the LAPD also provides support in processing 911 calls received. When the Communications Division receives a fire or paramedic emergency call, they connect callers with LAFD.

As shown in Figure 5, 911 calls are categorized into two categories: law enforcement services and fire/EMS services. 85% of LAFD's emergency responses are EMS requests. They respond to over 1,000 medical calls and transport over 600 patients to area hospitals per day.[44]

1. **Law Enforcement**: 911 Law Enforcement requests are responded to by LAPD and will yield two responses depending on the jurisdiction: law enforcement response or law enforcement with LA County Department of Mental Health, which is only available in certain neighborhoods of Los Angeles.
2. **LAFD EMS Bureau**: Housed inside the Los Angeles Fire Department, responds to Fire and EMS requests and will provide pre-hospital services, and if needed, transport patients to the nearest hospitals and emergency department. The EMS Bureau provides prehospital care with its 2,500 firefighter and EMTs, and 1,200 firefighter and paramedics.

Non-Emergency Services: 311 (Information Technology Agency)

While NotifyLA serves as a publicly-available connection between citizens and emergency services, 311 serves as a non-emergency equivalent to connect with a wide range of city services. The 311 System is a call center service run by the City of Los Angeles' Information Technology Agency (ITA) to connect Angelenos with various city services and provide the most factual and up to date information. The City of Los

44 "About EMS Bureau." Los Angeles Fire Department, www.lafd.org/about-ems-bureau. Accessed 8 May 2023.

Angeles established its first 311 call center in 2002 with the goal of providing an all-in-one location for residents to request and learn more about non-emergency services provided by different City departments.[45] As shown in Figure 6, Angelenos can either call or use a digital device to request either information or a service. Below are the current service request types and their corresponding department:[46]

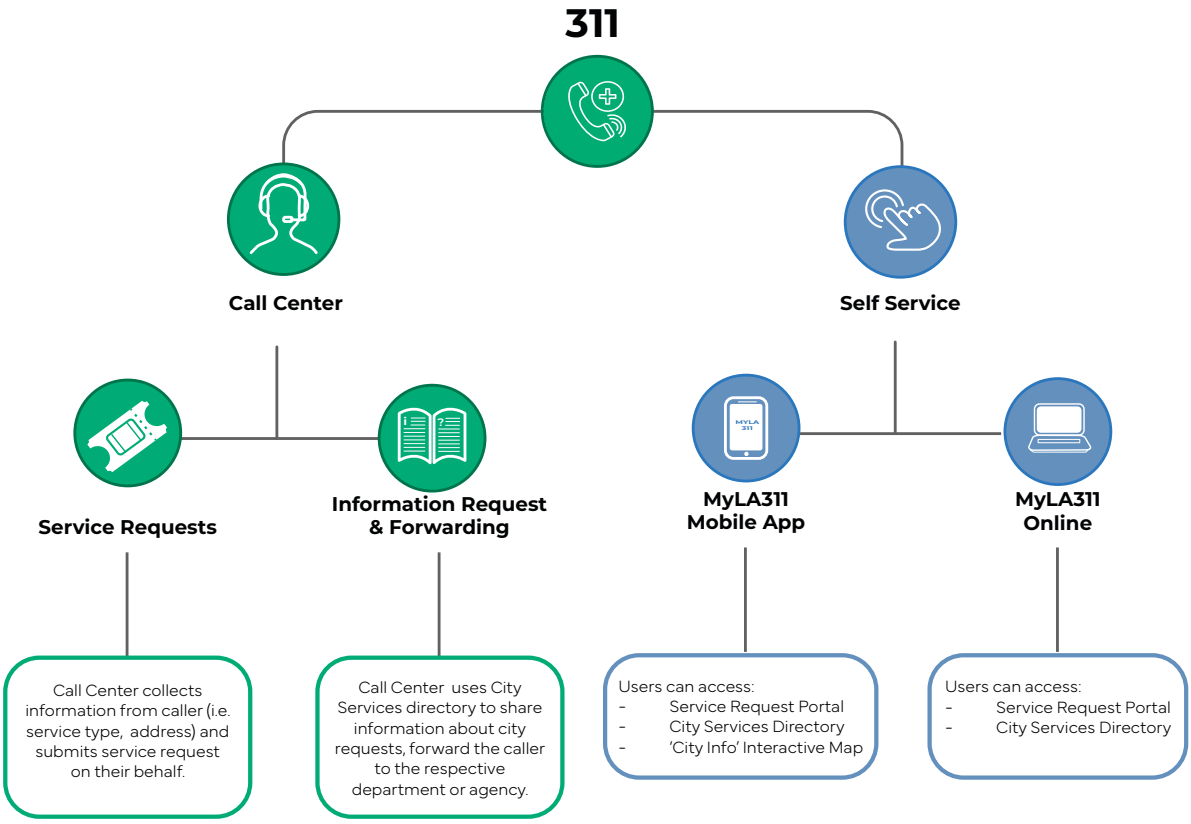
- Trash Pick Up (LASAN)
- Graffiti Removal (Office of Community Beautification)
- Potholes & Street Repair (StreetsLA)
- Parking Enforcement (LADOT)
- Police Complaint (LAPD)
- Fire Hazards (LAFD)
- Building Code Violations (LADBS)
- Housing Code Violations (LAHD)
- Issues at Parks (Recreation and Parks)
- Unsafe Sidewalks (Safe Sidewalks LA)
- Wage Theft (Bureau of Contract Administration)
- Utility Theft (LADWP)

The 311 digital platform consists of the 311 website or MyLA311 mobile app which is available in a variety of languages, including English, Spanish, Korean, Armenian, & Mandarin. In addition to department service information, the website includes informational articles used to disseminate non-emergency City announcements. For example, in preparation for extreme heat events, 311 provides information for relevant services and resources like cooling center locations. On February 8, 2023, we spoke with 311 Director Donna Arrechea to gain insight on how 311 services are distributed in the City of Los Angeles. She shared that the call centers receive both information and service requests and use their Knowledge Base to connect callers with the appropriate department or submit a service request on their behalf.

45 The 411 on 311: Calling for a Customer Service Approach (2021). City of Los Angeles Controller's Office. Accessed March 1, 2023 at https://controller.lacity.gov/audits/311

46 Download MYLA311 app! MyLA 311 Online Dashboard. (n.d.). Retrieved February 26, 2023, from https://myla311.lacity.org/portal/faces/home/dashboard?_afrLoop=805548019066889&_afrWindowMode=0&_afrWindowId=null&_adf.ctrl-state=10jceewn1d_1#!%40%40%3F_afrWindowId%3Dnull%26_afrLoop%3D805548019066889%26_afrWindowMode%3D0%26_adf.ctrl-state%3D10jceewn1d_5

Figure 6: 311 Processes in the City of Los Angeles



Early Warning Response: NotifyLA (Emergency Management Department)

The Emergency Management Department (EMD) serves as a coordinating force within the City of Los Angeles and manages the planning and logistics for the City's Emergency Action Plan. In 2009, to better streamline emergency communication with Angelenos, EMD established the City's primary automated early warning system for forecastable emergency events (including heat waves) known as NotifyLA. The system is designed to deliver alerts, warnings and instructional messages via voice messages, text messages, and/or email messages to registered residents and businesses within an associated geographic area during times of emergencies and disasters.

NotifyLA actively keeps EMD, Los Angeles Fire Department (LAFD), Los Angeles Police Department (LAPD), Los Angeles World Airports (LAWA) and LA Harbor connected when disseminating large scale emergencies or warnings to the general public via voluntary text, email and call messaging. In addition to opt-in alerts, NotifyLA

has authorization from FEMA to send Wireless Emergency Alerts (WEA) through participating phone carriers. When extreme events, like heat waves, or natural disasters occur and a WEA is activated by the city, alerts are sent through a federally-regulated communication network. All departments within Los Angeles have access to request an alert via NotifyLA by contacting EMD and following proper procedures and recently updated messaging. Types of messaging distributed to the public on this system include[47]–early warning notices, disaster notifications, evacuation notices, public health notices, and public safety notices of imminent or perceived threats to life and/or property.

Because NotifyLA uses the City's emergency 911 database, only land-line numbers are automatically included in the system. Residents wanting to receive notifications via cell phone, Voice over IP (VoIP) number or email, must register their phone numbers and/or e-mail addresses online for free via the NotifyLA website. The system's platform is managed by Everbridge, a software and public safety solution provider. Through Everbridge's Resident Connection database, the software company has access to over 200 million landlines, Voice over IPs (ex. internet), and mobile phones which emergency managers across the United States can access during times of emergency.[48] According to a report by the previous LA City Controller, Ron Galperin, as of June 2022, NotifyLA has access to approximately 1.7 million addresses through Everbridge's Resident Connect system, representing approximately 3 million separate phone lines; approximately 602,000 additional lines are accessible via NotifyLA's opt-in subscription.[49] Warning systems like NotifyLA help keep the public informed when disasters occur but are also used as a preemptive communication measure when needed, including during extreme heat events.

47 Sign Up to NotifyLA to Be Notified of Local Emergencies. City of LA Highlights Dashboard. (2023 February 20). Accessed on February 26, 2023 at https://lacity.gov/highlights/sign-notifyla-be-notified-local-emergencies

48 Follow-Up Audit — Alert and Aware: Modernizations to Improve NotifyLA, the City's Emergency Mass Notification System, 2022 Emergency Management. (2022 November 10). Accessed on February 26, 2023 at https://controller.lacity.gov/audits/follow-up-audit-alert-and-aware-modernizations-to-improve-notifyla-the-citys-emergency-mass-notification-system

49 ibid

CRITIQUES OF CURRENT INFORMATIONAL AND EMERGENCY RESPONSE SYSTEMS

For all the intentionality behind the design of these informational and emergency response City services, no system is perfect. Gaps in 911 and 311 services, as mentioned below, have emerged highlighting discrepancies for how well these emergency management systems are able to fulfill the goal of meeting the needs of all Angelenos. These services are meant to be equally accessible to all residents; however, how equitable access is to city services can be called into question. Below we have outlined critiques of both emergency and non-emergency services in the city of Los Angeles.

In addition to critiques compiled by public agencies, we observed three main issues during our initial research. First, across all agencies, consistent data reporting and record upkeep was lacking. Second, communication and outreach across all agency platforms was inconsistent. For example, each department has their own version of a heat campaign and relays educational information via different outlets, respectively, which can make information distribution confusing for residents. Thirdly, how resources are distributed compared to community needs and vulnerabilities does not always equate. We will expand on these three points throughout the chapter.

Critiques of 911 (LAFD, LAPD, EMD)

Although there are no recent official LA Controller reports that specifically focus on LAFD or LAPD regarding emergency response, several audits have been conducted to review EMS and EMD respectively. According to an analysis by the City Controller (Wendy Greuel) in 2012, response times were getting slower in which the share of EMS requests responded to within 5 minutes or less decreased from 62% to 57%. Although a recent audit hasn't been conducted, there has been news reporting on slower response times throughout the City. One article included quotes from LAFD paramedics claiming that wait times can be up to 10 minutes if you're "lucky," 15

minutes as being the most common response time, and 20 minutes response time becoming the "new normal."[50] LAFD paramedics attribute longer wait times to higher call volumes as call volumes have more than doubled while the number of fire stations has not increased.

In 2022, previous LA City Controller, Ron Galperhan, published a status report evaluating EMD as the primary department responsible for coordinating the City of Los Angeles' emergency planning and response. Some of the key critiques of this analysis found that EMD is falling behind in managing and responding to recommendations based on post-emergency assessments.[51] Furthermore, the report identified gaps in the City's protocols for mitigating disasters and how it coordinates with LA County agencies.[52]

Critiques of 311 (ITA)

A 2021 audit conducted by the LA City controller also found that 311 is not operating as efficiently as it could be. Reasons were summarized as follows:

1. **Better inter-departmental communication is needed**: Although all requests could have been processed by 311 in 2020, the Bureau of Santiation's call center still received over 700,000 removal requests.[53]
2. **The list of service request types is not exhaustive**: When residents call for information or a service that 311 is not familiar with, wait-times can increase and cause confusion among residents. This efficiency issue could be improved by working with ITA to redirect complex calls to the appropriate agency and by adding new request types that are commonly asked for. [3]
3. **Not all Angelenos are aware of the resources & services available**: More marketing and engagement strategies are needed to increase public awareness of 311 as a "one-stop-shop." [3]

50 Silva, Gina. "'It Happens Every Day': LAFD Paramedics Say 911 Response Times Continue to Rise." FOX 11 Los Angeles, 9 Mar. 2023, www.foxla.com/news/lafd-paramedics-say-911-response-times-continue-to-rise.

51 A Better Plan to Get L.A. Ready for Emergencies. (n.d.). Office of Kenneth Mejia, LA City Controller. Retrieved May 9, 2023, from https://controller.lacity.gov/audits/a-better-plan-to-get-l-a-ready-for-emergencies

52 ibid

53 Galperin, R. (2021, March). The 411 on 311: Calling for a customer-first approach. Office of Kenneth Mejia, LA City Controller. Retrieved February 26, 2023, from https://controller.lacity.gov/audits/311

SCHOLARLY CONTEXT FOR INFORMATIONAL AND EMERGENCY RESPONSE CRITIQUES

Many recent studies have explored the impacts of urban heat on emergency medical services in the context of emergency room visits and hospitalizations. A 2014 study found that between 2009 & 2010, alone, there were 8,251 emergency department (ED) visits for heat-stroke in the United States, which translates to about 1.34 ED visits per 100,000 individuals — the majority of which (63.1%) occurred between the months of July and August.[54] Extreme heat events have even contributed to excess ED visits and hospitalizations compared to non-heat events. A 2009 study found that the 2006 North American heat wave that lasted from mid-July to the end of August prompted an excess of 16,166 ED visits and 1,182 hospitalizations just in California.[9]

However, few studies have investigated the relationship between extreme heat events and emergency call volumes. A study done in Toronto, Ontario, Canada analyzed call data over a four-year period from 1999 to 2002 and found that call volumes on "oppressively hot days" (extreme heat days) increased ambulance call volumes by 10% over normal levels.[8] Additionally, the study found that calls on normal days spatially differed from those on extreme heat days. Exploring the possible impacts of extreme heat on emergency call volumes and spatial distribution in the context of Los Angeles is a central goal of this chapter.

In addition to utilizing 911 data, local governments are beginning to develop more direct place-based heat mitigation strategies. Specifically, researchers are increasingly focusing on 311 information systems as a tool to support local government's emergency management and community needs during disasters.[55] The request-based format of 311 systems allows both researchers and practitioners to

54 Wu, Xian & Brady, Joanne & Rosenberg, Henry & Li, Guohua. (2014). Emergency Department Visits for Heat Stroke in the United States, 2009 and 2010. Injury Epidemiology. 1. 8. 10.1186/2197-1714-1-8.

55 Wu, W.-N. (2021). Does Citizens' 311 System Use Improve Satisfaction with Public Service Encounters?—Lessons for Citizen Relationship Management. International Journal of Public Administration, 44(8), 665–673. https://doi.org/10.1080/01900692.2020.1744644

evaluate changes in immediate needs during, before, and after a disaster, increasing community resilience. Schellong and Langenberg (2007) highlight that 311 systems have improved accessibility to up-to-date information and critical government services during disasters. Furthermore, as shown in Baghersad et al.'s (2020) neighborhood comparison of government response to Hurricane Wilma, analyzing 311 data can expose critical gaps both in services and response times across geographic areas.[56]

In addition to assessing the efficiency of 311 systems during disaster situations, several studies have focused on how residents engage with this non-emergency system. Panukeu et al. (2021) analyzed 311 system request services in Orange County, Florida, during the COVID-19 pandemic, noting the potential of this system to efficiently distribute relevant information and explore how communities respond to different types of disaster.[57] Zobel et al. (2017) used 311 data to perform a multidimensional study that captured infrastructure resilience in urban areas by analyzing frequency and type of post-disaster public service requests. Most recently, in 2022, Kianmehr et al. used 311 service requests to identify the impacts of the 2021 heatwave in Vancouver, British Columbia on frequency and types of service requests, looking at the association between weather conditions (wind, temperature, precipitation) and the volume of non-emergency service requests.[13]

Although the above literature shows different ways 311 data can be used in disaster management analyses, few 311 studies are associated with extreme heat, especially within the City of Los Angeles.

56 Baghersad, M., Zobel, C. W., & Behara, R. (2020). Evaluation of Local Government Performance after Disasters.

57 Pamukcu, D., Zobel, C. W., & Ge, Y. (2021). Analysis of Orange County 311 System service requests during the COVID-19 pandemic. Proceedings of the 18th International Conference on Information Systems for Crisis Response and Management. https://par.nsf.gov/biblio/10294149-analysis-orange-county-system-service-requests-during-covid-pandemic

DATA AND METHODS

Inquiries and Scope

The main objective of this preliminary study is to explore whether 911 and 311 call volumes increased during periods of extreme heat within the past 5 years (2018-2022). We also explore the geospatial relationship between hotspots (if any) of 911 and 311 call volumes and heat-vulnerable populations identified by the CVA.

In this study, we use quantitative methods to address three key research questions:

- Are there more calls to 911 and 311 systems during extreme heat events?
- If so, where are these additional calls coming from?
- If there is an uneven distribution of additional calls, which communities and populations are most impacted?

Our statistical methods are based upon methods used to estimate deaths and emergency room visitation associated with heat events as there is a research gap in associating 911 or 311 call volumes with heat events. As such, these methods are exploratory with respect to these particular phenomena and aim to provide the groundwork for future research.

For the purpose of analyzing 911 and 311 call volumes during extreme heat events and developing a clear understanding of where these calls are coming from, we use a sequential approach to data processing and analysis. Each step of analysis builds on the previous phases to answer our fundamental questions. Throughout the following sections, each step of our analysis is built upon three fundamental variables:

- **Heat exposure**: using air temperature and relative humidity collected from weather stations to identify which parts of the city meet a "heat day" threshold on specific days.
- **Call volumes**: comparing daily 911 and 311 call volumes during extreme heat events in the last 5 years
- **Spatial and demographic vulnerabilities**: community demographics and vulnerable communities in the potential 'hotspots' we identify during the process of our analysis.

Acquiring Data

To effectively compare call volumes on heat days vs. non-heat days we first need to answer two key questions with our data. What are the call volumes in a given area on each day of our study period (2018 - 2022)? In those areas, which days are considered heat days?

To answer these questions, we obtained data from a variety of sources which are summarized in Table 1 below. With the assistance of CEMO, we procured data by request from the Los Angeles Fire Department (LAFD) and from the Synoptic Data Mesonet API (a well documented and publicly accessible source for obtaining selected weather observations from participating weather stations). The availability and specificity of some aspects of 911 data is limited because it is considered healthcare information and is governed under HIPAA, a federal law that protects sensitive patient information from being disclosed without their consent.[58] The result was a dataset with call volumes for each day in our study period (2018 - 2022) for each fire station district in the City. A further summary of our primary data, the variables, and constraints is shown in Table 1 below. Fire station districts are a representation of the area served by any given fire station. There are 102 districts in the City of LA, distributed such that any point in a given district is within an accessible distance of the fire station serving that district.

Of note, 311 service request data is readily available through public access data portals, but our analysis required information requests, which are not published publicly. Service requests include only requests for city services such as trash collection and street light repairs; however no services recorded in 311 are directly applicable to heat responses. We are primarily interested in calls for information, assuming that individuals may call 311 to get information about their nearest cooling center or other cooling resources.

For service requests, residents connect to 311 online or over the phone, but information requests are made only via phone. Service requests require collecting detailed information, including street address to ensure that appropriate city

58 "Health Insurance Portability and Accountability Act (HIPAA)." Centers for Disease Control and Prevention, www.cdc.gov/phlp/publications/topic/hipaa.html#:~:text=The%20Health%20Insurance%20Portability%20and,the%20patient's%20consent%20or%20knowledge.

Table 1: Data Used in Analyses

Data Source	Variable	Geography	Temporal Resolution	Limitations
911 Call Volumes (LA Fire Dept.)	- Date - Fire Station District - Call Sub-Category - Volume	Fire Station Districts (polygons)	Date	This data is disaggregated by day, fire station district, and call type. However, it does not include more granular or flexible geography or times of day.
311 Information Requests (ITA)	- Creation Date - Service Request Number - Service Request Address - KB Article - Neighborhood Council - Comments	City wide, with some data containing neighborhood council information (points)	Date and Time (to the minute)	This data includes information for individual calls and includes call reasons, however most calls do not contain location data.
Weather Station Data (Synoptic Mesonet API)	- Date-time (near hourly) - Station ID - Relative Humidity - Air Temperature	Weather Stations (points)	Date and Time (to the minute)	This data is highly organized and flexible. In its raw form it contains every reported observation of temperature and humidity for every selected weather station. This allows for a great deal of analytical flexibility. However, this data is also limited by the number of stations in a given region. Our study area has 10 stations, therefore, some microclimate effects are negelected.
Los Angeles Climate Vulnerability Assessment (Social Vulnerability Index)	- Asthma - Cardiovascular disease - Children - Disability - No health insurance - Living in group quarters - Older adults - Older adults living alone - Outdoor Workers - Renters - Rent burden - Poverty	Los Angeles City Census Tracts	N/A	The geography of this data does not neatly align with fire station districts and thus the data requires preprocessing.

services are provided, yet, information requests do not follow the same robust data collection procedure. However, based on conversations with key stakeholders at the 311 Call Center, the vast majority of calls to 311 are information requests — not service requests. Most calls from individuals attempting to connect with city resources are recorded as information requests, but these requests do not contain the detailed data recorded in service requests.

We requested 311 information request records from Donna Arrechea (who worked closely with us to select and provide the necessary data) and explored a subset of the information requests made to the city during our five year study period, choosing calls that were coded to selected relevant 311 knowledge base articles including:

- Education and Personal Development - Library Services
- Health and Human Services - Seniors
- Health and Human Services - Homeless
- Human & Health Services: Youth
- Human & Health Services: For Persons with Disabilities
- Public Safety and Emergency Services: Fire Control and Prevention
- Public Safety and Emergency Services: Emergency Medical and Rescue
- Public Safety and Emergency Services: Emergency Preparedness
- Recreation - Recreation Centers

Due to the current 311 recording procedure, only 36% of our selected calls provided by the City include the caller's neighborhood council district. Because of this limited information, we chose to aggregate these calls to the city level to explore the relationship between heat and call volumes, and provide some descriptive statistics on call volumes per neighborhood council district based on the subset of calls that include geographic information.

Data Aggregation

Combining these data to analyze call volume differences between heat events and other times requires joining these datasets by date and geography. Geography in particular is a key concern for our data. Fire districts are a geography based largely upon the distribution and travel times between fire stations, and they do not neatly align with traditional political or analytical divisions such as council districts or census

tracts, much less heat exposure levels within the city of LA. We use these fire district geographies as the base geographic unit of analysis, interpolating weather station and population data to this geography to later analyze call volumes. Due to limitations in the data, our 311 analysis is conducted at the citywide scale.

We then use weather station data to calculate heat in each fire district for every day of the study period and use this to explore correlations between heat and call volumes as well as to define heat events. From there we can validate the correlation in the data and explore excess calls. Further details can be found in the Analytic Process section, Appendix D, and our project repository.

ANALYTICAL PROCESS

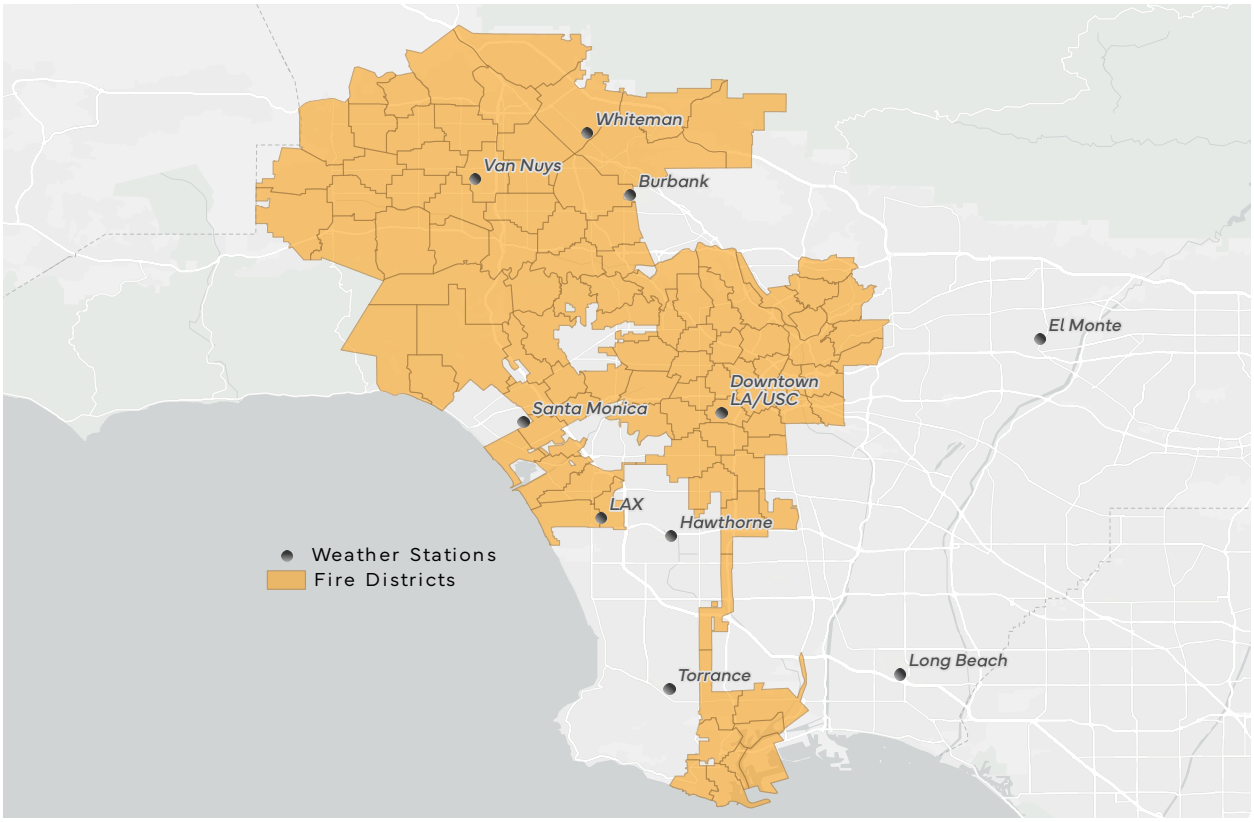
Because of the variation of content within our datasets, we segment our analytical procedures and process into four steps:

1. Heat Exposure,
2. 911 Call Volumes,
3. 311 Call Volumes, and
4. Spatial and Demographic Vulnerabilities.

Step 1 - Heat Exposure Analysis

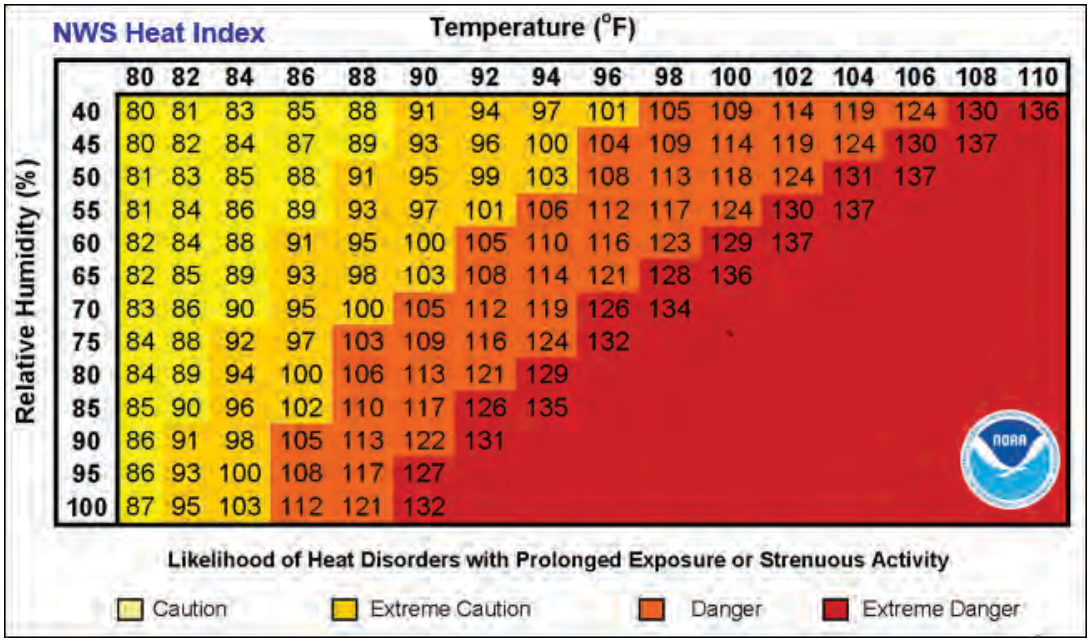
Our analysis of heat involved pulling and exploring data from weather stations available from Mesonet through the Synoptic Data API. We used data from 10 weather stations in Los Angeles proper and the surrounding areas including: Downtown LA/ USC, the Los Angeles Airport (LAX), the Burbank Airport, Van Nuys, Whiteman, Santa

Figure 7: Weather Stations in the Los Angeles Region



Monica, El Monte, Hawthorne, Long Beach, and Torrance. A selection of these stations and their locations in relation to the LAFD Fire Station districts are shown on the map in Figure 7.

Figure 8: NOAA Heat Index



The NOAA Heat index table displays the 'feels like' temperature based on relative humidity and temperature. At a temperature of 90F with a relative humidity of 60%, the temperature will feel like 100F, warranting a heat alert.

From these stations we obtained the observed air temperature and relative humidity readings and calculated a heat index. This heat index, defined using the NOAA methodology, involves calculations with a piecewise function of air temperature and relative humidity with manual adjustments for set air temperature and humidity thresholds.[59] The code used to pull and process this data can be found in our project GitHub repository. An approximate display of the relationship between air temperature and humidity and heat index values can be found in Figure 8. After calculating this heat index we aggregated the data to find the daily high and low heat index for each station.

Each station collects and reports air temperature and relative humidity data at different intervals, with wide variation. Downtown LA reports, on average, every 50

59 Heat Index Equation. (n.d.). Retrieved May 19, 2023, from https://www.wpc.ncep.noaa.gov/html/heatindex_equation.shtml

minutes, but Burbank, Van Nuys, LAX, Hawthorne, Long Beach, and Santa Monica report approximately every 5 minutes and El Monte, Torrance, and Whiteman report every 2 hours. The temporal granularity of this data is meaningful, but our analysis aggregates to select only the maximum heat index calculated for each day from each station.

We interpolate data between stations using an inverse distance weighting (IDW) algorithm to estimate the heat index across the city. This is a frequently used metric that yields relatively good results when compared to other non-geostatistical methods.[60] However, our calculations are a function of distance, and do not explicitly consider topography, coastal effects, or urban morphology (e.g., trees, development density, etc.) except inasmuch as those factors influence the air temperature at weather stations. Other interpolation methods can take these factors into account, but are more complicated to produce. For this first exploration of heat and emergency calls we opt for the simplified approach.

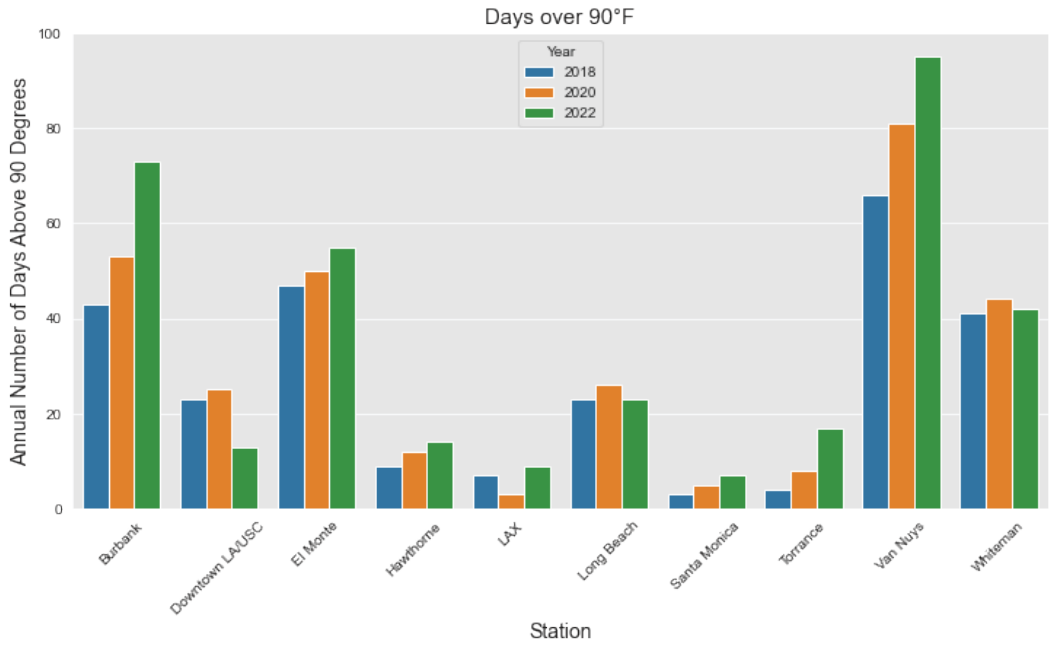
An important consideration in this chapter is that air temperature and heat index are regional-level metrics that do not express direct heat exposure, local thermal comfort, or physiological equivalent temperatures. Rather, a heat index is useful for comparing neighborhood-scale heat across a region. In this chapter, we examine the relative heat conditions in fire districts without considering how the built environment might affect residents' experiences of the heat.

In general, as shown in Figure 9, weather stations in the San Fernando Valley (Burbank, Van Nuys, and Whiteman) had many more days over 90°F than areas in central and West LA. This follows the trend we might expect based upon anecdotal evidence and geographic conditions.

In 2022, there was a greater number of days over 90°F than in previous years. Van Nuys experienced temperatures over 90°F for more than a quarter of the year. That said, heat days are highly variable year to year. While 2022 was an extremely hot year, 2021 had significantly fewer days over 90°F, with some weather stations (Hawthorne, LAX, and Santa Monica) not rising above 90°F at all while Van Nuys still had 70 days over 90°F.

60 Hsu, S.-C., Mavrogianni, A., & Hamilton, I. (2017). Comparing Spatial Interpolation Techniques of Local Urban Temperature for Heat-related Health Risk Estimation in a Subtropical City. Procedia Engineering, 198, 354–365. https://doi.org/10.1016/j.proeng.2017.07.091

Figure 9: Number of Days over 90°F, 2018-2022



After this initial exploration of the number of heat days by weather station, we utilized an inverse distance weighting algorithm to approximate the heat index for any given point across the city of LA based upon the daily heat index of these weather stations. The resulting rasters created through this process were further processed to assess the average heat index within a given fire station district, as illustrated in Figure 10.

We define heat events as days where two or more consecutive days had a daily maximum of at least 90°F within a given fire district because the longer the heat wave lasts, the greater the mortality risk is.[61] [62]

We also conduct sensitivity testing of our heat day definition to understand the impacts of setting a heat day at 95°F or 100°F instead of at 90°F based on the definitions Heat Advisory and Heat Alert by the Los Angeles County Public Health Department and the City of LA EMD as shown in Table 2.[63]

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61 Centers for Disease Control and Prevention (CDC). (2013). Heat illness and deaths – New York City, 200-2011. MMWR, 62(31), 617-621.

62 Ming, Wai-Kit, et al. "Does physical activity reduce the risk of prostate cancer? A systematic review and meta-analysis." BMC Public Health, vol. 17, no. 1, 2017, p. 929. BMC, doi:10.1186/s12889-017-4129-7.

63 City of Los Angeles EMERGENCY OPERATIONS PLAN. "ADVERSE WEATHER Hazard Specific Annex." July 2020, https://emergency.lacity.gov/sites/g/files/wph1791/files/2021-04/adverse_weather_annex_2020_final.pdf

Figure 10: Heat Interpolation Process

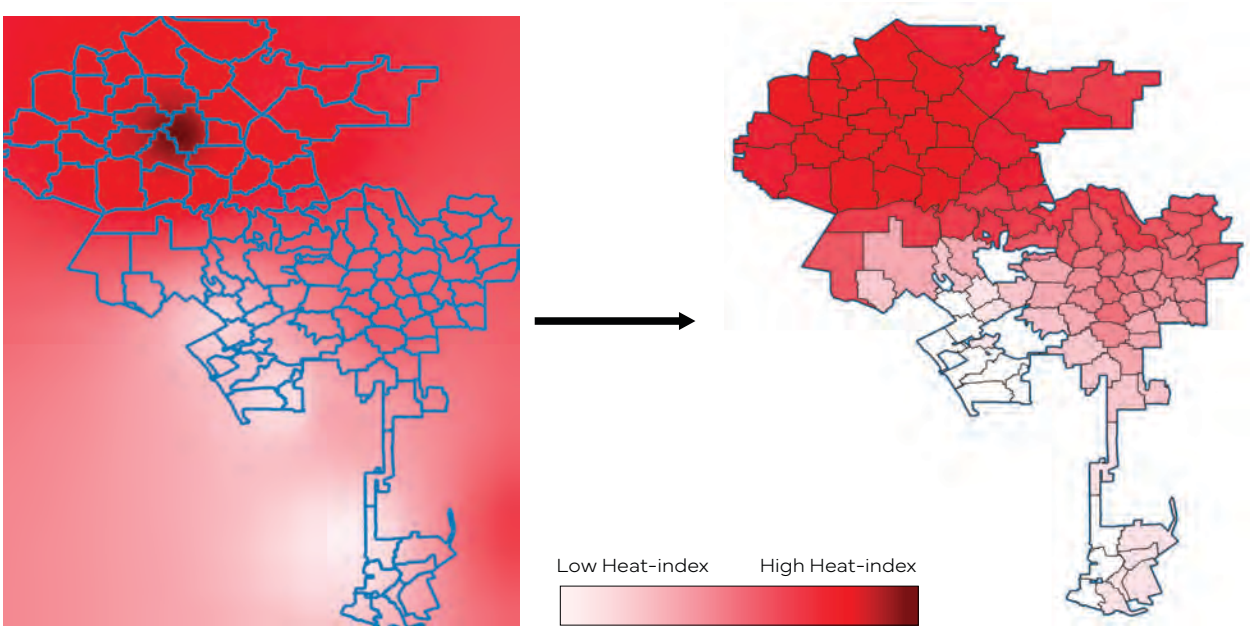


Table 2: Heat Alert & Advisory Thresholds, Los Angeles County

Geography	Heat Advisory	Heat Alert
LA Basin	1 day at 95°F	2 days at 95°F
Valleys/Mountains/ Deserts	1 day at 100°F	2 days at 100°F

Step 2 - 911 Call Volume Analysis

The Los Angeles Fire Department tracks the number of 911 calls, including emergency and non-emergency responses for all 114 stations in Los Angeles. Here, we analyze the total number of incidents for 2018 to 2022.

Figure 11 displays the flow used to finetune the granularity of our data analysis. The data includes the daily call volumes for each fire district by incident category. This analysis requires incident counts by individual days and at some level of geographic detail so we can manipulate and analyze the data to observe patterns at reasonable geographic and temporal scales. The figure to the right illustrates the different levels of granularity we can analyze.

The map shown in Figure 12 highlights the districts that have landed in the 10 top districts with the highest volume of calls between 2018-2022. Districts 9, 64, 66, 57, 11, 46, 33, and 89 have consistently landed in the top 10 over the last 5 years, while fire district 27 has been in the top 10 four times in the past 5 years, district 51 twice in the past 5 years, and district 39, 98, 10, and 4 only once.

Figure 11: Data Granularity Flowchart

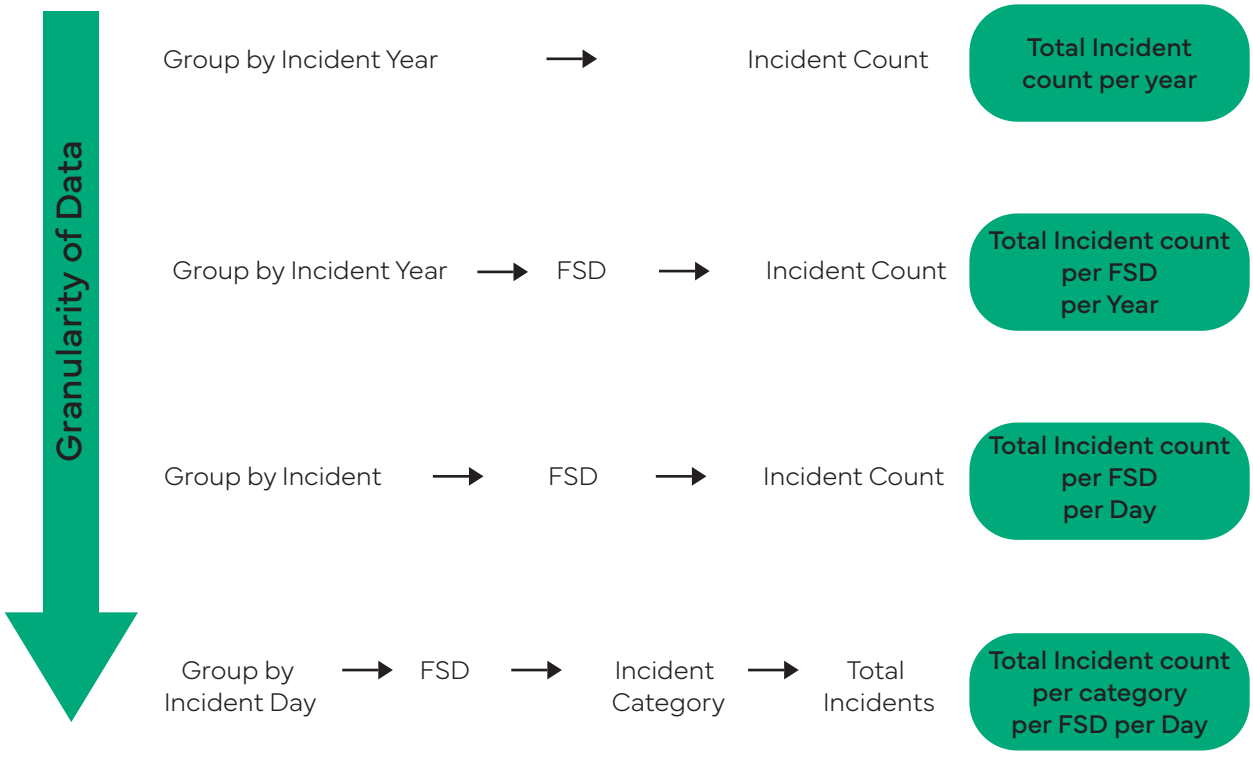
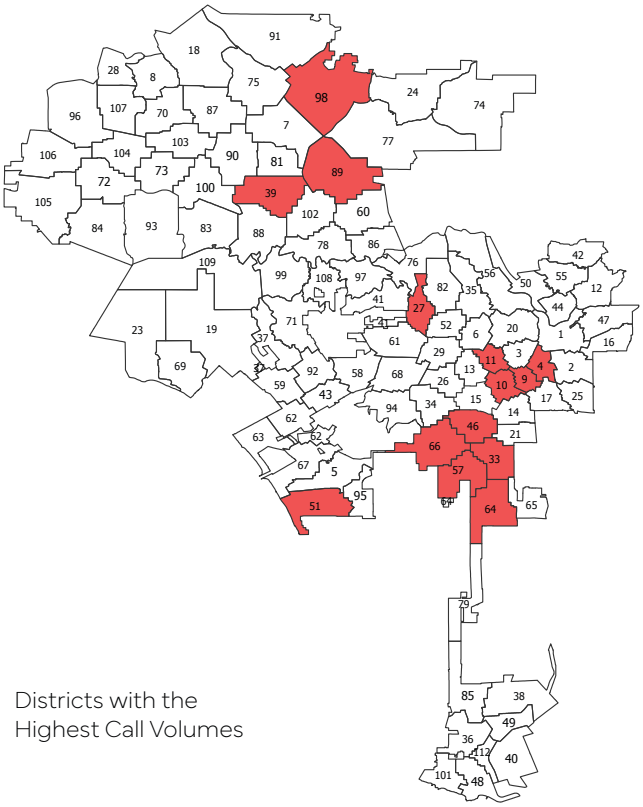


Figure 12: Districts with the Highest Call Volumes



We then joined daily call volumes of EMS calls with our heat data to explore correlations between call volumes and heat on a district by district level as well as across the city as a whole. Further we looked at both absolute call volumes as well as normalized call volumes by population, calculating calls per 10,000 people.

This latter metric, while useful in areas, is not a reliable variable to normalize because the number of fire station districts have very low populations but high levels of activity. A key example is district 51, which is the area including and immediately surrounding the Los Angeles Airport (LAX). This district has an estimated 216 residents yet consistently has a high volume of daily calls (an average of approximately 20 daily EMS calls), leading to drastically high calls per 10,000 people (averaging over 1000). This is likely because calls related to LAX are included in this data.

This district isn't alone as an "outlier;" other districts with inordinately high average call rates include the port and parts of downtown. This is likely due to these areas having low residential populations but significant activity (such as travelers at LAX

and employees in Downtown). To mitigate the effects of these districts in invalidating the significance of our results, we calculate most metrics of our analysis either as aggregated up to the city level or within individual fire station districts to ensure that we are comparing "apples to apples."

We verify the significance of our results using a series of one tailed independent t-tests on the average call volumes on heat vs non-heat days (explored on both a citywide and fire district level). Across the city as a whole and within a given fire station district, "n" is the number of days in our study period (1827).

After verifying the relationship between variables we calculate "excess" calls as the number of calls greater than an expected call volume on a non-heat day in a given district. This expected call volume is calculated as one standard deviation above the mean for call volumes on non heat-days.

Step 3 - 311 Call Volume Analysis

The 311 data we obtained is composed of 46,955 calls for the years 2019 to 2023, over a span of 1902 days. Only 14,264 calls contain neighborhood council district information. Because of the limited geographic detail, we aggregated the data to a citywide level to explore the average citywide daily call volume during our entire study period. We then compare call volumes during extreme heat days vs. non-heat days. To differentiate between an extreme heat day vs. normal day, we apply a 90°F daily maximum temperature threshold and use weather data from the Downtown Los Angeles weather station as a proxy for the temperature across the entire city of Los Angeles. Although we acknowledge that not all areas in the city will experience the same temperature based on geography or proximity to the ocean, DTLA is our most central weather station and is a baseline metric to define citywide heat. We also explore the relationship between temperature and call volumes using a linear regression model as well as one tailed independent t-test as described above in our 911 analysis.

Step 4 - Spatial and Demographic Analysis

Climate-vulnerable populations need more access to resources in order to adapt to extreme heat events. The Social Vulnerability Index of the Los Angeles County Climate Vulnerability Assessment (LA CVA) maps population characteristics and social vulnerability to show communities that may be most impacted by climate change impacts. The LA CVA defines high climate vulnerability as "a combination of increased exposure to climate hazards; high sensitivity, or susceptibility, to negative impacts of exposure; and low adaptive capacity, or ability to manage and recover from exposure."[64] This includes various demographic information, health characteristics, and socioeconomic factors. We mapped all CVA variables related to high sensitivity to extreme heat illness or low adaptive capacity, shown in Table 3, in an effort to better understand the communities in fire districts with high 911.

Other variables from the Los Angeles County Climate Vulnerability Assessment - Social Vulnerability Index were not included since they don't directly make someone sensitive or reduce adaptive capacity [See Appendix B].

64 Los Angeles County Climate Vulnerability Assessment. https://ceo.lacounty.gov/wp-content/uploads/2021/10/LA-County-Climate-Vulnerability-Assessment-1.pdf.

Table 3: LA County Climate Vulnerability Assessement Variables

Variable	Definition	Reason
Asthma	Age-adjusted rate of emergency department visits for asthma	High Sensitivity
Cardiovascular disease	Age-adjusted rate of emergency department visits for heart attacks per 10,000	High Sensitivity
Children	Percent of people 18 and under	High Sensitivity & Low Adaptive Capacity
Disability	Percent of persons with either mental or physical disability	High Sensitivity & Low Adaptive Capacity
Living in group quaters	Percent of persons living in (either institutionalized or uninstitiutionalized) group quarters	Low Adaptive Capacity
No health insurance	Percent of persons without health insurance	Low Adaptive Capacity
Older adults	Percent of people 65 and older	High Sensitivity & Low Adaptive Capacity
Older adults living alone	Percent of households in which the householder is 65 and over who and living alone	High Sensitivity & Low Adaptive Capacity
Outdoor workers	Percentage of outdoor workers - agriculture, fishing, mining, extractive, construction occupations	Low Adaptive Capacity
Renters	Percentage of renters per census tract	Low Adaptive Capacity
Rent burden	Percent of renters paying more than 30 percent of their monthly income on rent and utilities	Low Adaptive Capacity
Poverty	Percent of the population living in a family earning below 100% of the federal poverty threshold	Low Adaptive Capacity

List of LA County Climate Vulnerability Assessment (CVA) variables related to high sensitivity to heat-illness or limited adaptive capacity when exposed to extreme heat.

RESULTS

We summarize the results of our analysis in the following sections: 911 calls attributable to heat, 311 calls attributable to heat, and the relationship of these analyses to demographic variables and health impacts. In exploring the relationship between heat and call volumes for both 911 and 311 we must first validate that a relationship appears to exist. 911 call volumes demonstrate a noticeable relationship; however, this data is noisy, especially when comparing between fire station districts. Nonetheless, we verify that a positive correlation between 911 call volumes and heat exists at the 99% confidence level and that there are statistically significant higher average call volumes on heat days vs non-heat days whether defining heat days with a 90°F, 95°F, or 100°F threshold. On the other hand, we do not find a definitive relationship between 311 call volumes and heat. Initial regression analysis does not show an immediate relationship; however, when performing a one-sided t-test, we find that there are statistically significant greater average 311 call volumes on heat days and events over 90°F than on non-heat days. Note this analysis is exploratory and more research will need to be done with both 911 and 311 data to confirm the relationship between heat and call volumes (or lack thereof) and its strength.

Table 4: 911 Call Volume Summary Statistics

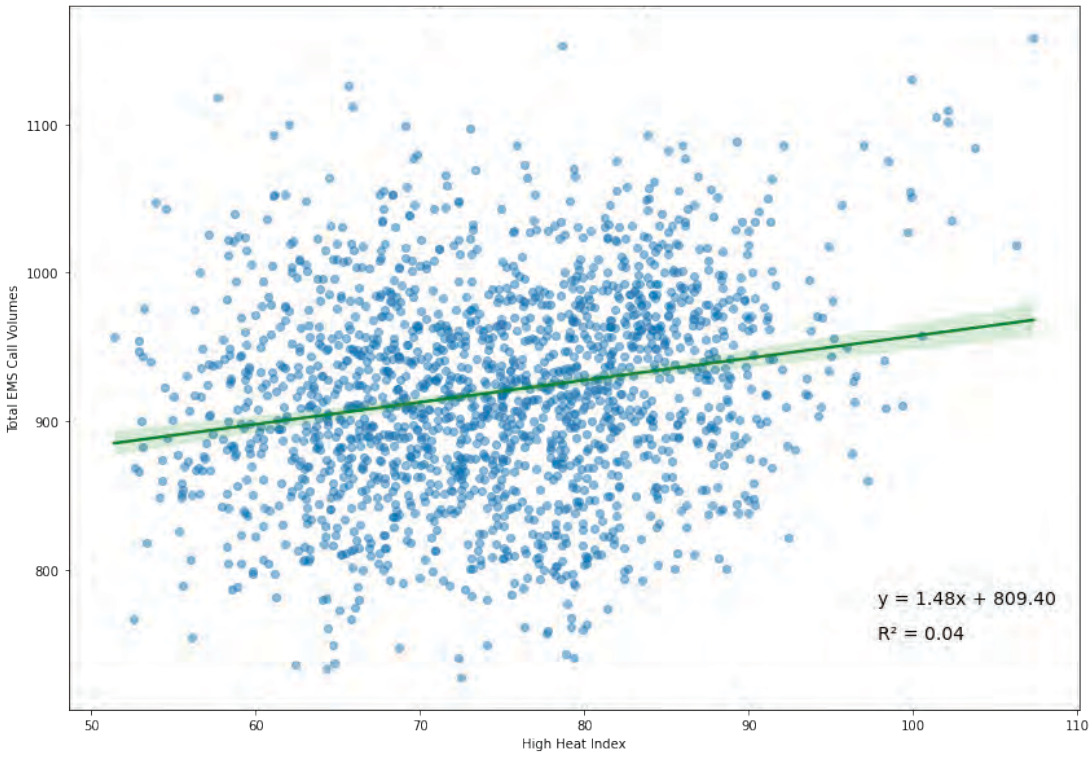
		Heat Day	Non-Heat Day
Number of Days		47	1779
Number of Calls	mean	974.81	918.27
	sd	75.86	67.62
	min	860	728
	25%	918	872
	50%	950	918
	75%	1031	965
	max	1158	1153

911 Call Analysis

Is there a relationship between heat and EMS call volumes? On a citywide level, our analysis suggests the answer is definitely yes. When looking at the city as a whole, shown in Table 4, there were 47 heat event days (as defined as the average heat across Fire Station Districts being above 90°F for at least two days) in the study period. These days had a higher mean call volume as well as a higher minimum call volume, however, both heat events and non-heat events had similar maximum call volumes.

A linear regression on daily EMS call volumes for the city plotted by the average high heat index across fire station districts on those days, Figure 13, demonstrates that there is a positive correlation between EMS call volumes and heat ($P < 0.001$). However, it also demonstrates the wide variation in this data. The days with the highest call volumes are not exclusively days of high heat, but hotter days are generally more likely to be high volume days.

Figure 13: Citywide EMS Call Volumes by Heat Index

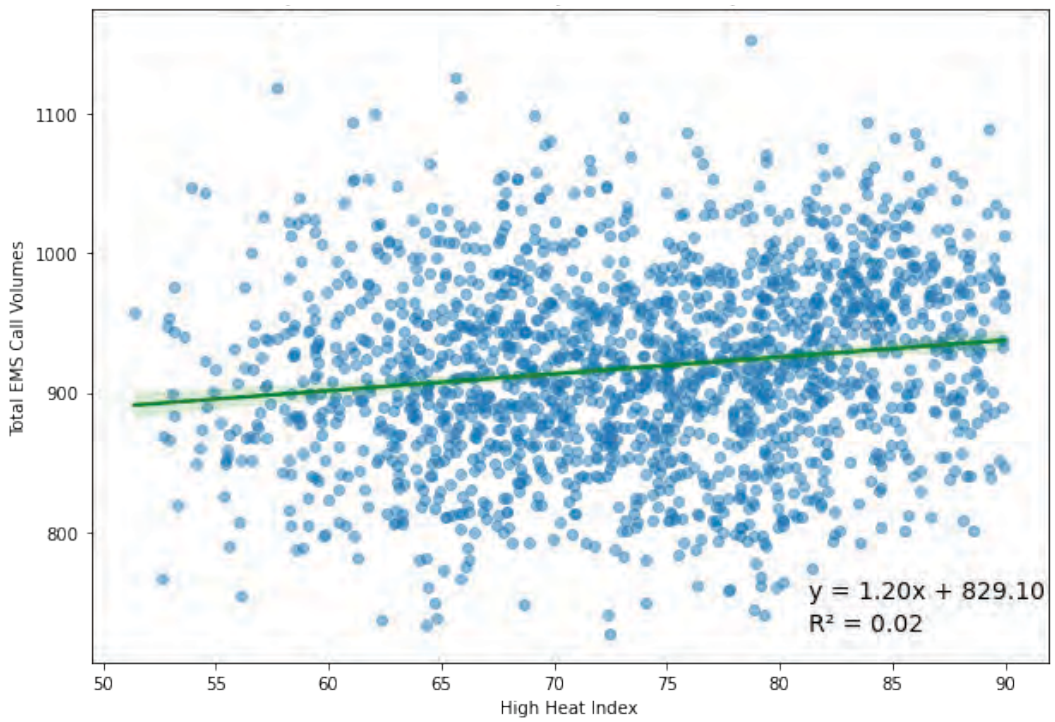


Scatter plot showing Citywide EMS call volumes by range of the high Heat Index.

The relationship can be further shown when splitting the data on the 90°F threshold, shown in Figure 14. For the days below 90°F there is both a lower coefficient of the regression and a lower R-squared value. The R-squared values represent how well the regression model predicts the outcome of the dependent variable. In our case, it predicts an increase of 809 excess calls per an increase of 1.48°F. This indicates that for days below 90°F, the heat index is less related to call volumes. The days over 90°F, shown in Figure 15, play an important role in contributing to the coefficient and significance of the overall regression. This can be further shown when we look at days over 90°F alone. When we do this, there is a very strong relationship between call volumes and heat index. Heat index is correlated to call volumes on hot days, and less so on cooler days.

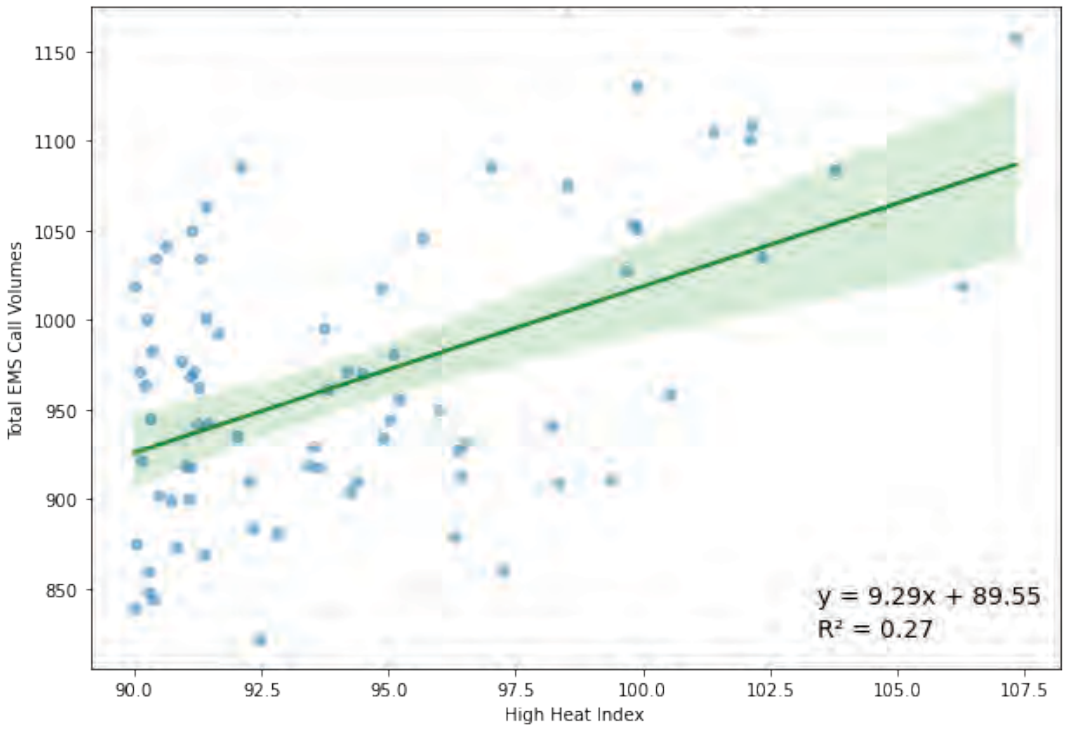
These initial plots of the data are also representative of Los Angeles' temperate climate. There were no days in the study period where the average temperature was below 50°F, and the frequency with which the average temperature climbs above 90°F is low. However, when it does climb above 90°F, call volumes are generally higher overall.

Figure 14: Citywide EMS Call Volumes by Heat Index (Days under 90F)



Scatter plot showing Citywide EMS call volumes below 90°F by Heat Index.

Figure 15: Citywide EMS Call Volumes by Heat Index (Days over 90F)

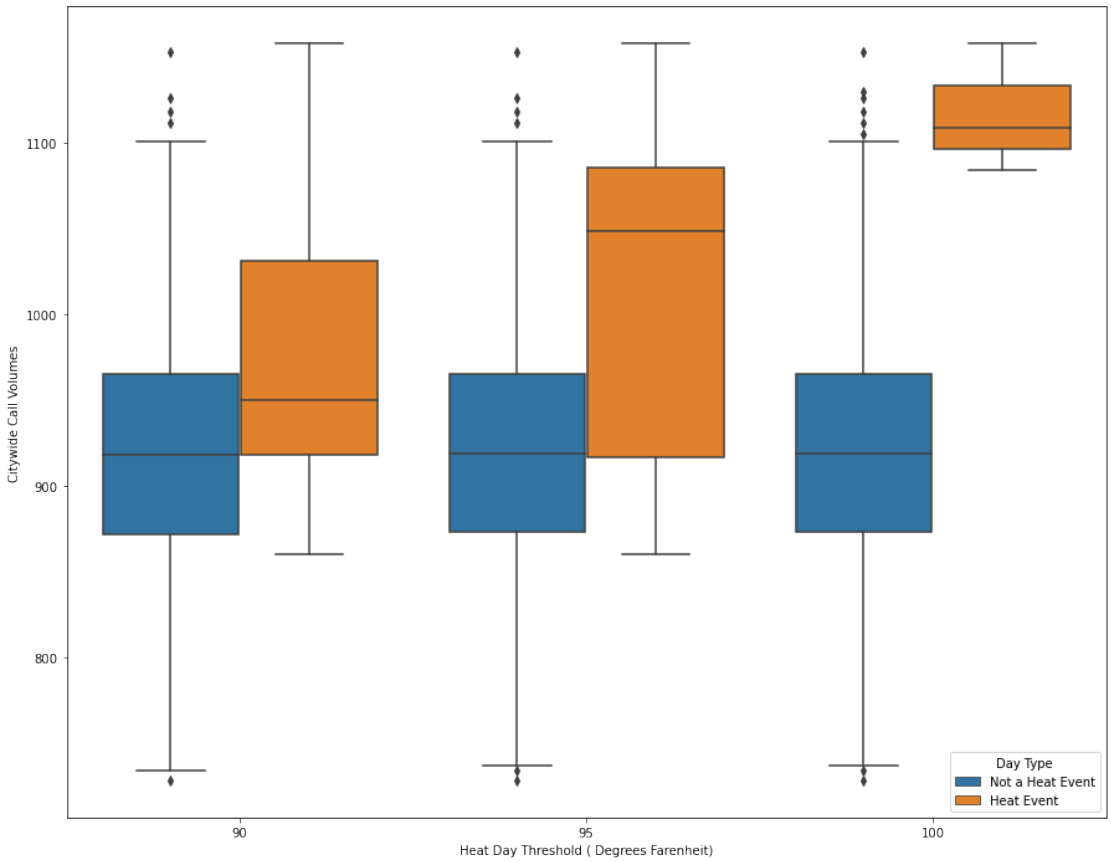


Scatter plot showing Citywide EMS call volumes above 90°F by Heat Index.

This can be further seen when comparing the average number of calls for non-heat days to heat days. Figure 16 below demonstrates the distribution of call volumes on heat vs. non-heat days as differentiated by a series of heat thresholds. Each heat threshold here is calculated as the second or greater consecutive day above that temperature threshold for the city as a whole.

The lowest heat threshold employed here, 90°F, demonstrates a significant difference in the average call volumes between heat and non-heat days. When calculating a one tailed t-test with alpha equal to 0.05 we can reject the null hypothesis ($p < 0.001$). There are statistically significant greater average call volumes on heat days and events over 90°F than on non-heat days. It is also interesting to note that the lower bounds of the distribution on heat days for each definition is much higher than that of non-heat days. This validates that while the impact of heat on 911 call volumes grows with heat, even our lowest tested heat threshold had meaningfully more calls on heat days.

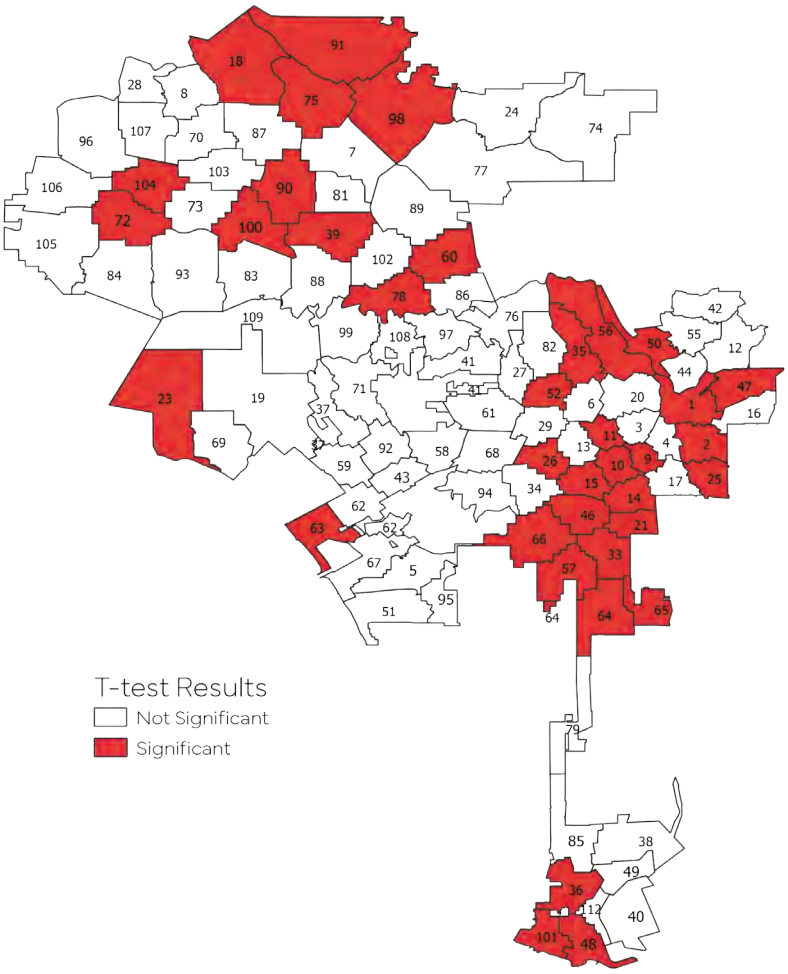
Figure 16: Call Volume Distribution by Heat Day Threshold



Validating citywide effects of the commonly-used 90°F threshold is critical for the next steps of our analysis in setting a baseline threshold with noticeable effects. This baseline threshold plays a key role in determining the number of heat days in the study period as well as how and when different geographies are analyzed for excess calls. For example, parts of the San Fernando Valley had almost one full year (352 days) over 90°F over the course of our five year study period (19% of our study period). But, it's also important to validate the pattern of emergency calls regionally.

The San Fernando Valley is overburdened when it comes to heat, especially in comparison to coastal areas. That said, within any given fire station district, the statistical significance between call volumes on heat and non-heat days can vary widely, when utilizing a 90°F threshold, 37 out 102 fire districts (36%) have statistically significant greater average call volumes on heat days than non-heat days as shown in Figure 17.

Figure 17: Fire Districts with More Calls on 90F Heat Days



These districts represent a wide range of locations across the City of LA: parts of the San Fernando Valley (including the hottest districts), South Central LA, and places near the coast. This further validates the use of a 90°F threshold for determining excess calls, demonstrating that a diversity of places around the city have demonstrated statistically significant greater average calls on heat days when determined with a 90°F threshold.

Excess Calls

We estimate the following number of total excess calls in the City of LA from 2018 to 2022 due to heat:

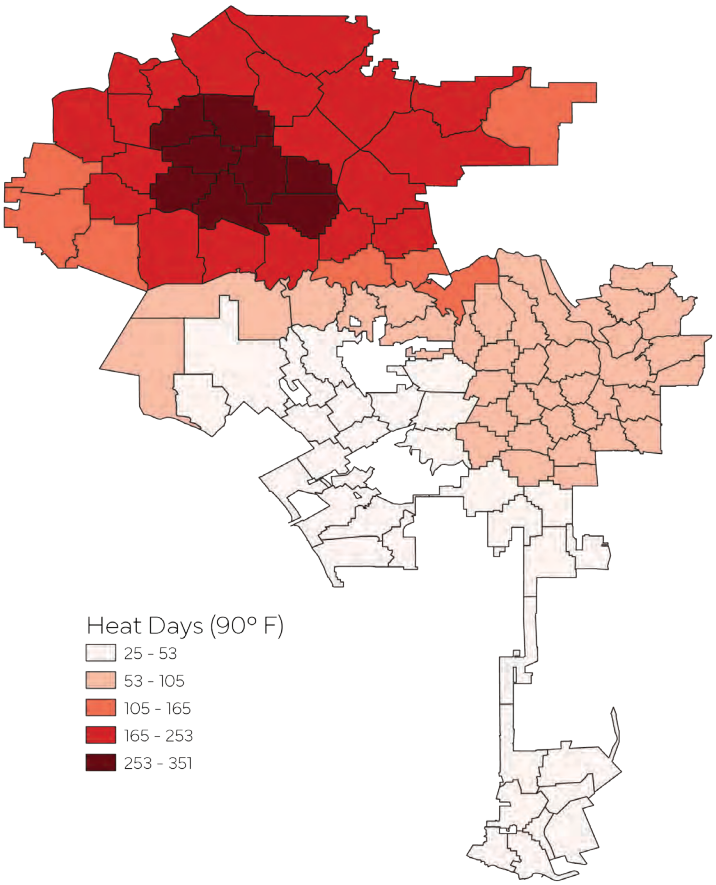
Table 5: Excess 911 Calls by Heat Threshold

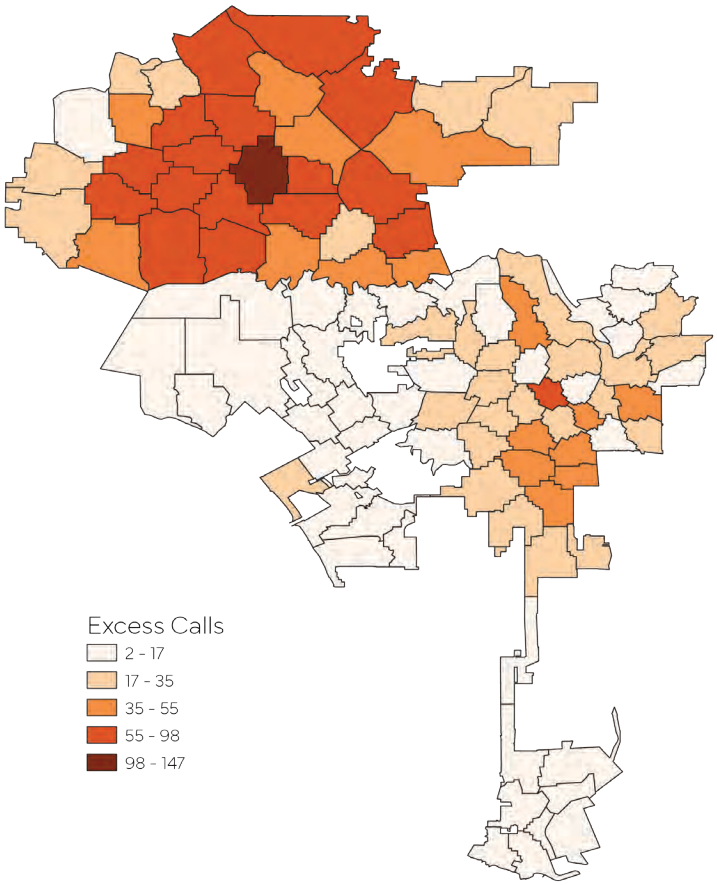
Threshold	90°F	95°F	100°F
Total Excess Calls (2018 - 2022)	3291	1197	389
Percent of Total Calls in Excess	0.2%	0.07%	0.02%

The total number of calls excess calls over the study period when defining heat at various thresholds. The declining number of excess calls at higher thresholds is due to the lower incidence of days meeting those definitions.

Using a 90°F threshold, Figure 18 shows these excess calls are distributed around the city in a pattern consistent with the distribution of heat, with the most coming from the Van Nuys area. However, excess calls do not spatially align with overall call volumes, which are concentrated in South Central LA, as shown in Figure 19.

Figure 18: EMS Calls by Fire District, 2018-2022

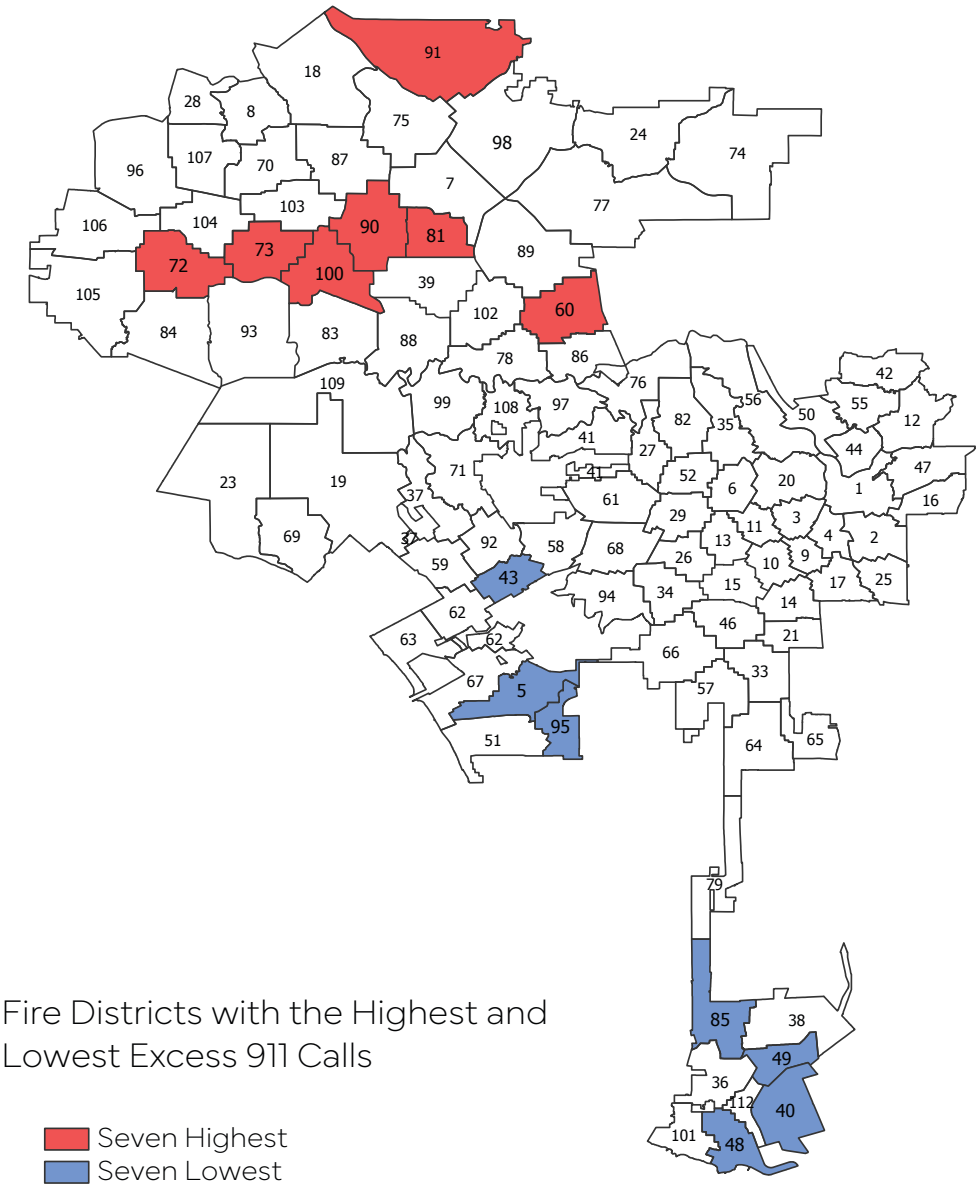




Comparing 911 Results To the Distribution of Vulnerable Communities

To better understand the communities living in the fire districts with the most excess 911 calls during days that go above 90°F, we analyzed data from the Social Vulnerability Index of the Los Angeles County Climate Vulnerability Assessment (CVA), which maps populations who have high sensitivity and low adaptive capacity to the effects of climate change, for the seven districts with the highest and lowest excess 911 calls (refer to Figure 20).

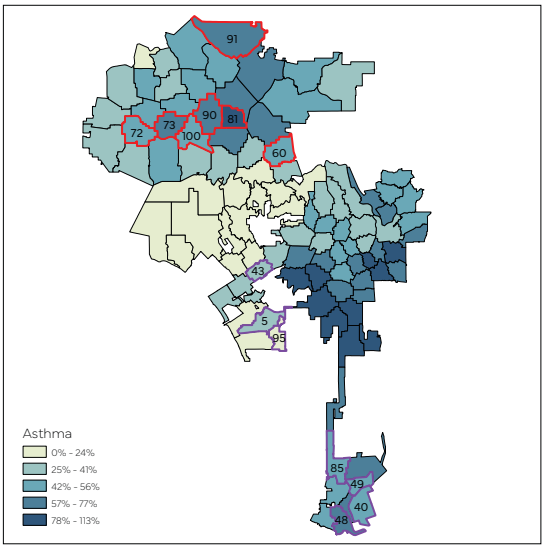
Figure 19: Fire Districts with Highest and Lowest Excess 911 Call Volumes

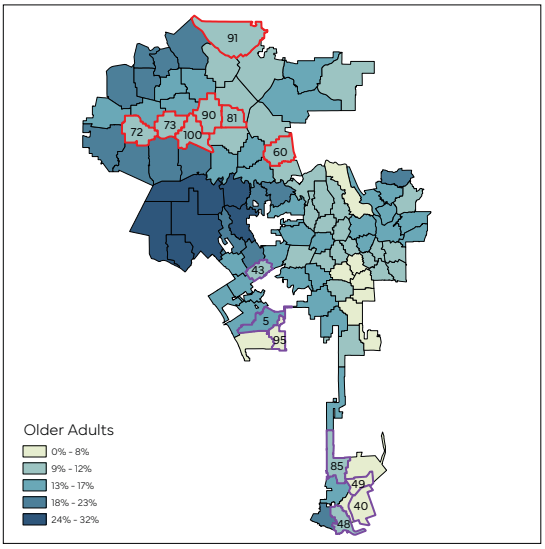


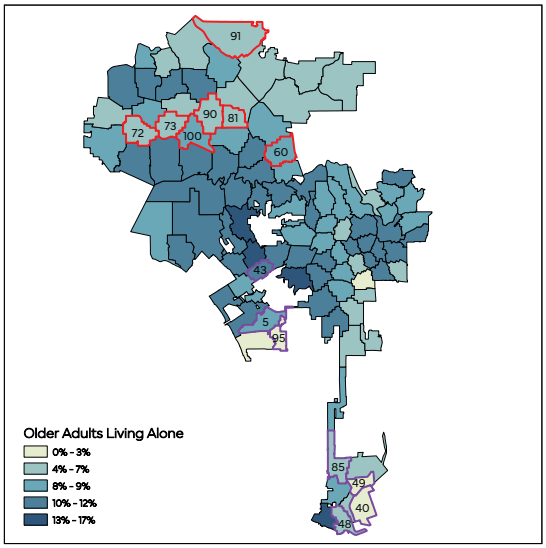
The seven fire districts with the most excess calls during extreme heat events were all located in the San Fernando Valley (SFV). The predominant ethnic group in the SFV are Hispanics (92.8%) and the median household income is $60,655.[65] When looking at variables from the CVA that specifically indicate high sensitivity or low adaptive capacity to extreme heat illness, the seven fire districts with the most excess calls reported percentages that went above the fire district averages for most variables (refer to Table 6). The seven districts all have a percentage of children that exceeds the fire district average, except for district 60 (located in the North Hollywood area). However, the seven districts had a smaller percentage of older adults and older adults living alone than the fire district average. Additionlly, the seven districts with the most excess calls all went beyond the fire district average for percentage of asthma, except for district 72 (located around Canoga Park) and district 60. District 90, 81, and 100 (located next to each other between the Northridge, Reseda, and Panorama City area), report percentages of asthma that go almost 20% above the fire district average. All the seven districts went beyond the fire district average for percentage of cardiovascular disease. Only three fire districts, 90, 72, and 60, were below the fire district average for percent with disability. Finally, looking at socioeconomic factors like percent of people who are renters, percent rent burdened, and percent of people living in poverty, the seven fire districts with the most excess calls show high vulnerability within most of the districts. District 100 (located near Reseda) is the only district below the average when examining for people who are rent burdened. Three districts, 91, 100, and 73, were below the fire district average for percentage of renters. Only two districts, 91 and 100, were below the average for percent in poverty. None of the seven fire districts were above the baseline for percentage of people living in group quarters. While all seven districts, except district 60, went beyond the fire district average for outdoor workers.

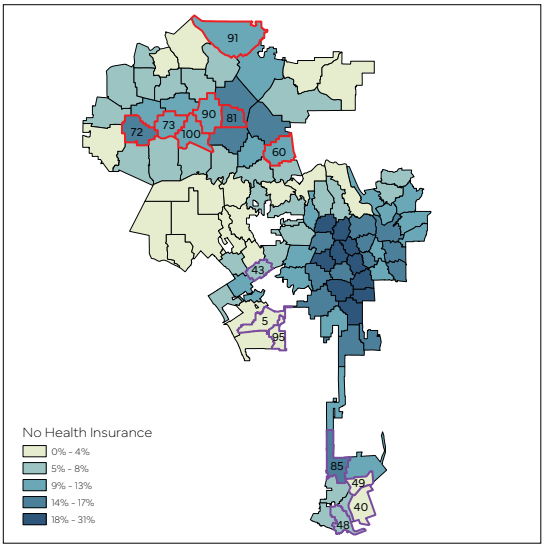
65 "San Fernando, CA." Data USA, datausa.io/profile/geo/san-fernando-ca. Accessed 19 May 2023.

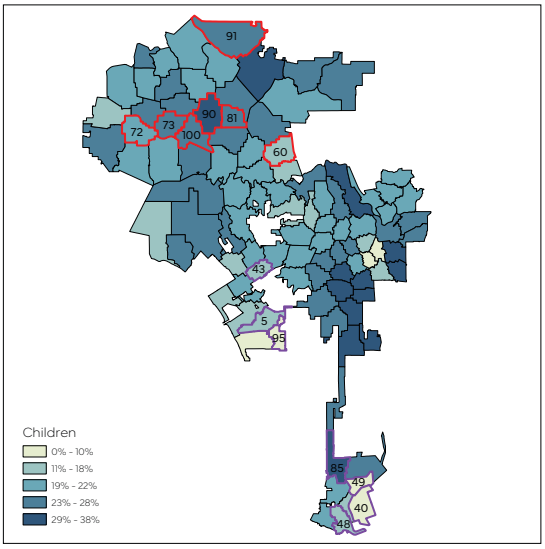
Figure 20: Climate Vulnerability by Fire District











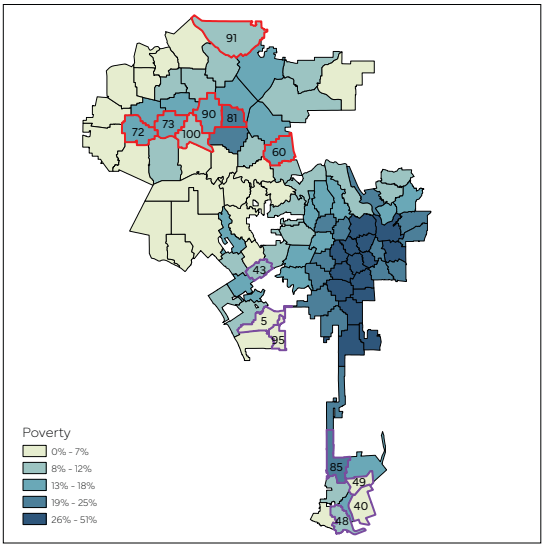
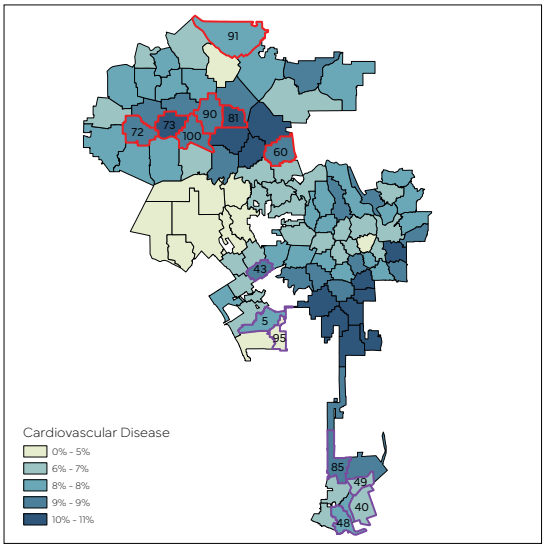
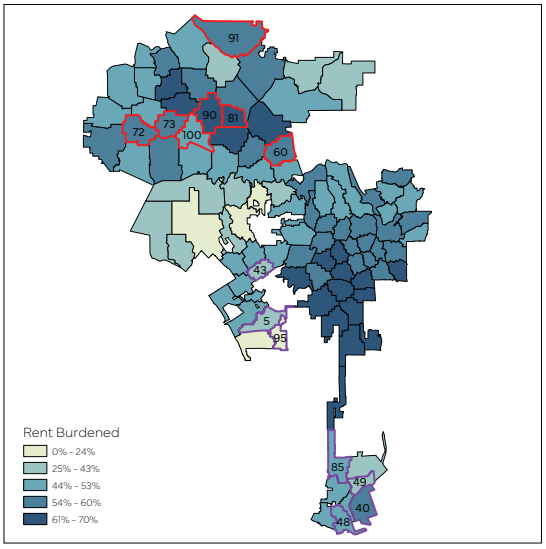
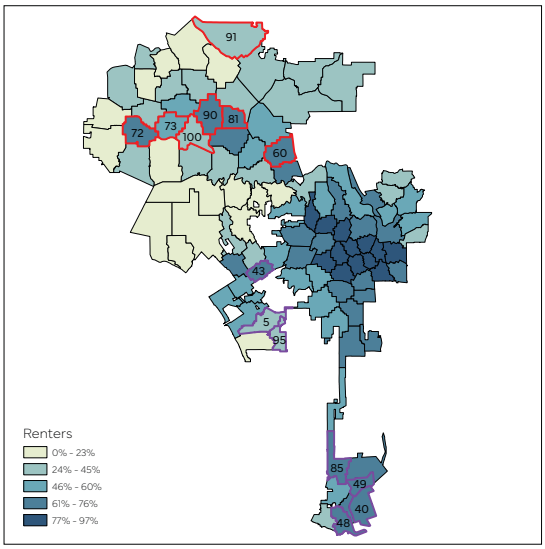
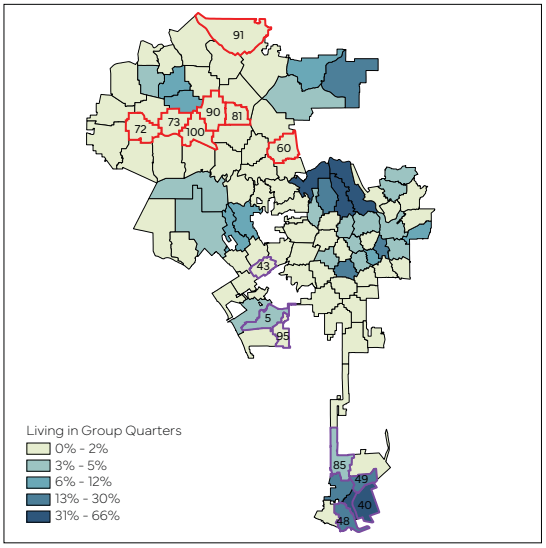


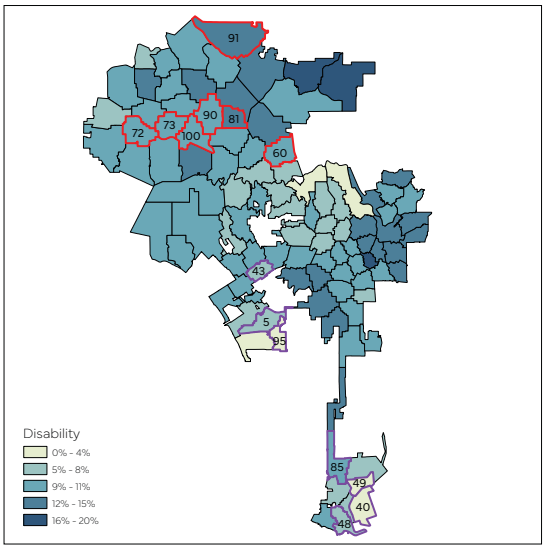
Figure 20: Climate Vulnerability by Fire District (cont.)











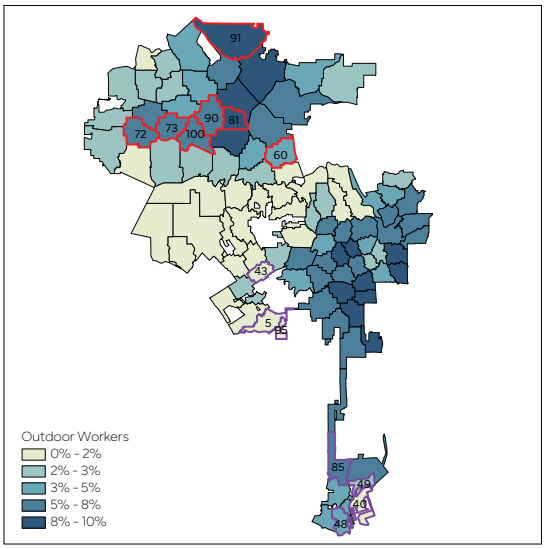


Table 6: Summary Statistics for Highest Call Volume Fire Districts								
District	**90**	**91**	**81**	**72**	**60**	**100**	**73**	**Baseline**
Excess Calls	147	98	93	89	86	82	82	
Children	30%	28%	27%	22%	18%	26%	25%	22%
Older Adults	10%	11%	9%	11%	11%	12%	12%	14%
Older Adults Living Alone	7%	6%	7%	7%	8%	8%	7%	9%
Asthma	71%	64%	92%	47%	46%	56%	73%	48%
Cardiovasc	9%	8%	11%	8%	8%	8%	11%	7%
Disability	9%	12%	12%	9%	9%	10%	10%	10%
No Health Insurance	12%	10%	16%	13%	10%	9%	12%	9%
Rent Burden	62%	53%	63%	54%	60%	49%	59%	51%
Renters	64%	32%	63%	61%	73%	41%	50%	51%
Poverty	15%	12%	20%	15%	17%	11%	17%	15%
Group Quarters	1%	2%	0%	0%	1%	1%	1%	5%
Outdoor Workers	6%	8%	10%	7%	4%	6%	6%	4%

While most climate vulnerability indicators exceed the fire district average in the districts with the most excess calls, the opposite is true for the fire districts with the least amount of excess calls (refer to Table 7). The seven fire districts with the least excess calls were mostly located in a cluster around the San Pedro and Harbor City area, and another cluster in the Westchester and Palms area. District 85 (located west of Carson) was the only district that exceeded the baseline for percent of children. Similarly, only district 5 (located in the South Bay) exceeded the fire district average for percent of older adults. The seven fire districts with the least excess calls did have higher percentages when looking at indicators for preexisting conditions. Four out of the seven districts, districts 5, 43, 85, and 48, are at or above the fire district average for percent of cardiovascular disease. Three districts, districts 40, 85, and 48, have percentages that are above the fire district average for percent of asthma. On the other hand, none of the seven fire district went above the average for percent of people with a disability. Additionally, all of the seven fire districts with the least excess calls went above the average for percentage of renters, except for district 5 and 95. However, only two fire districts, districts 40 and 48, reported at or above the

Table 7: Summary Statistics for Lowest Call Volume Fire Districts

District	40	49	5	43	95	85	48	Baseline
Excess Calls	2	2	2	3	3	4	5	
Children	1%	6%	17%	15%	10%	29%	17%	22%
Older Adults	6%	4%	15%	11%	4%	8%	9%	14%
Older Adults Living Alone	0%	1%	9%	10%	2%	5%	7%	9%
Asthma	56%	47%	34%	33%	15%	52%	65%	48%
Cardiovasc	6%	6%	7%	8%	3%	8%	7%	7%
Disability	0%	2%	8%	7%	4%	9%	7%	10%
No Health Insurance	0%	3%	2%	8%	3%	13%	7%	9%
Rent Burden	54%	33%	35%	43%	20%	51%	48%	51%
Renters	69%	75%	32%	72%	27%	69%	61%	51%
Poverty	0%	5%	7%	11%	6%	20%	9%	15%
Group Quarters	66%	28%	3%	1%	0%	2%	18%	5%
Outdoor Workes	0%	2%	1%	1%	1%	5%	5%	4%

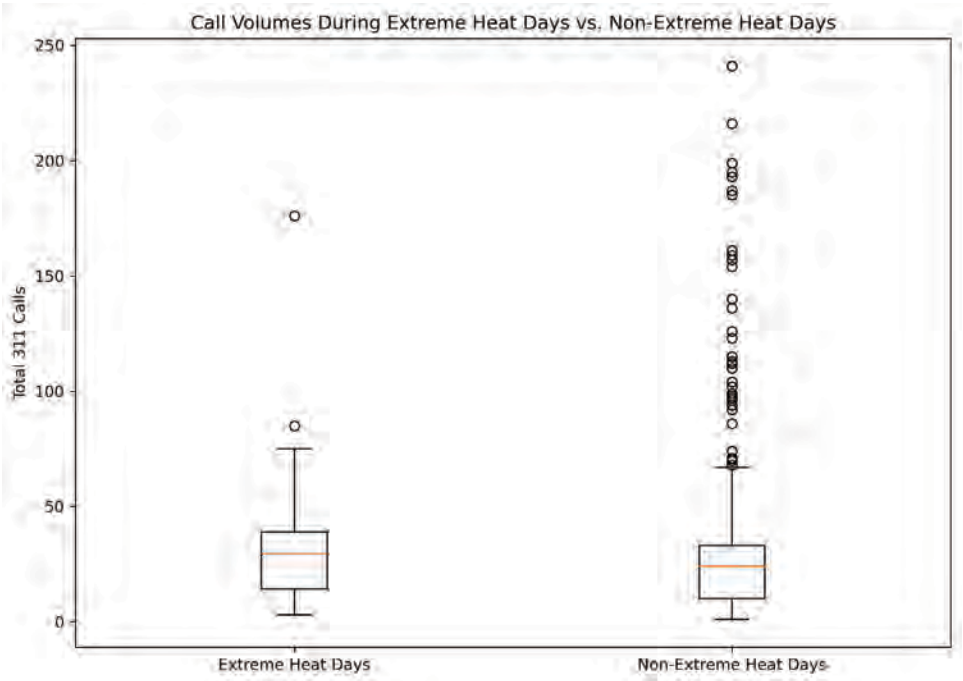
fire district average for the percentage of people who are rent burdened. District 85 is the only district that reported more than the baseline for percentage of people living below the poverty line. Districts 40, 49, and 48, went far above the baseline for percentage of people living in group quarters. Only two districts, districts 85 and 48, were above the fire distract average for outdoor workers.

While excess calls relate strongly to heat exposure, our preliminary analysis reveals that they also might be vary based on demographic and vulnerability indicators. Qualitatively, fire districts with the most excess calls during days that exceed 90°F had a positive relationship with higher percentages of climate-vulnerable populations, and districts with the fewest excess calls had lower percentages of vulnerable populations. We suggest expanding this analysis across the city to understand how neighborhood-scale social and health factors are related to excess calls, and in turn might motivate more spatially-specific heat mitigation and emergency efforts.

311 Analysis

Since our 311 call data is at a different geographic scale, we must analyze our results separately from the 911 call data. We investigate the relationship between the total call volumes and a daily maximum temperature of 90°F for our entire study period through a linear regression model (Appendix C). At first inspection of the data displayed in Figure 22, we did not see a correlation between call volumes and extreme heat, as originally hypothesized.

Figure 21: Call Volumes on Heat Days & Non-Heat Days



Number of calls during non-heat days and extreme heat days with a daily maximum temperature of 90°F.

Next, we disaggregate our data by extreme heat days by applying a 90°F daily maximum temperature threshold. As shown in Table 8, we find 82 extreme heat days and 1716 non-heat days between 2019 and 2023. Although the standard deviation, median, and mean are similar between both data sets, there is greater variability in call volumes during a non-extreme heat day, as evident by the many outliers in the boxplot above.

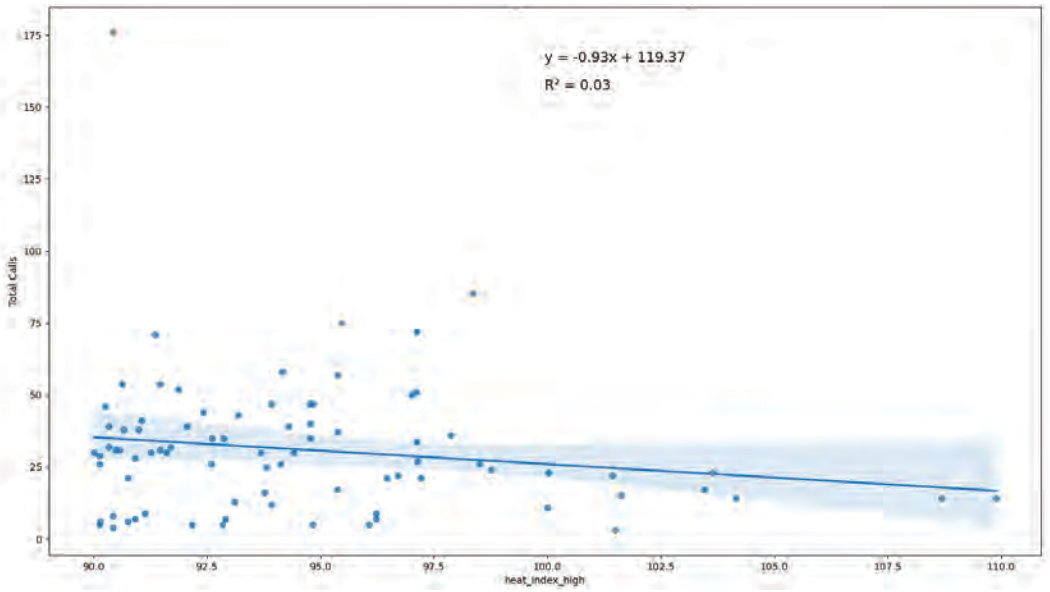
We conduct a one tailed t-test and reject the null hypothesis ($p < 0.018$). There are statistically significant greater average call volumes on heat days and events over 90°F than on non-heat days.

Table 8: 311 Call Volume Summary Statistics

		Heat Days	Non-Heat Days
Number of Days		82.00	1716.00
Number of Calls	mean	30.69	24.92
	sd	24.13	21.09
	min	3.00	1.00
	25%	14.25	10.00
	50%	28.50	24.00
	75%	39.00	33.00
	max	175.00	240.00

Again, we explore the relationship between call volumes and the daily maximum temperature for our extreme heat days dataset, and non-extreme heat dataset (Figure 23). We observe no reportable correlation between call volumes and temperature for either non-extreme heat days or extreme heat days.

Figure 22: Citywide 311 Call Volumes Regression



DISCUSSION AND LIMITATIONS

Our analysis provides a first-of-its-kind exploration into the potential connection between city services and residents during periods of high heat through the lens of 911 and 311 systems. Because of the exploratory nature of our study, a great deal of the work was done to develop novel methods to begin to decipher unexplored data and relationships. The outcome of this effort can serve as the foundation of additional explorations into the relationships between heat and emergency response, both using 911 and 311 data but also potentially urgent care visitation, Google search trends data and Twitter data.

911 — Emergency Services Analysis

Our emergency services analysis finds that there is a strong relationship between heat and 911 calls, even at the lowest heat day threshold of 90°F. This is promising for the state of future research into the relationship between heat and emergency services. We also see that most excess calls come from areas with the greatest number of days of heat. This is reasonably expected from this analysis, however, it isn't the only variable at play. There are likely also some relationships to explore in the relationship of overall call volumes to excess call volumes.

However, there are challenges to comparing fire station districts. Population does not adequately account for overall variations between districts because call volumes are also likely linked to other factors such as land use, employment and events (such as games, concerts, and protests) that we do not analyze here. Future research should investigate the driving factors behind call volume variance across districts. This would also allow us to develop a clearer understanding of the relationship between vulnerability factors and call volumes.

That being said, the implications of identifying these areas of high excess calls are many. It is clear that heat plays an important role in call volumes even below the thresholds set by EMD. Within the Valley in particular, 90°F heat days are still a statistically significant threshold for determining higher average calls. These areas also experience heat much more frequently.

This begs a key question in the emergency response to heat events: should EMD consider a heat event as a widespread emergency, or is it best conceptualized as a series of individual health emergencies? Furthermore, how do we balance conceptions of heat as an "emergency" vs as a chronic stressor?[66] How we answer these questions will have drastic policy implications for responses to the public health impacts. Our research shows that there are more 911 calls due to heat even on days that are not currently designated as heat emergencies. Perhaps addressing heat as a chronic stressor in policy might play a key role in addressing this. Future investigation into the 911 system and call data can also provide a key understanding of how heat events impact demand for city services, and where this demand might best be prioritized.

Limitations

Our analysis is necessarily narrow in scope given the timing of our project. We focus on a narrow definition of heat that a) does not incorporate other factors affecting heat exposure, including the built environment or resources (such as car ownership or access to air conditioning) and b) is an interpolated estimate. As we have calculated it, our data is likely to under-estimate heat in places farther from weather stations, including East and South LA. We also consider air temperature, a variable that does not change significantly across small scales in response to built environment factors such as tree canopy, urban canyons, direct sun exposure, and building material. We therefore do not consider thermal comfort of residents or pedestrians, and the ways in which heat exposure translates directly to physical health. Rather, we examine neighborhood-scale patterns of temperature relative to one another.

Furthermore we do not explore controlling by other temporal factors such as community events (protests, sports games, etc) or even by population or an ambient call volume growth rate. A great deal of variation in call volumes may be attributed to these temporal factors. The limitations of controlling for community events was noted to us in conversations with FireStatsLA in initial conversations about obtaining data and has hindered their analysis into this topic as well. Future research should seek to address these additional factors in their analysis.

66 Annie Bolitho & Fiona Miller (2017) Heat as emergency, heat as chronic stress: policy and institutional responses to vulnerability to extreme heat, Local Environment, 22:6, 682-698, DOI: 10.1080/13549839.2016.1254169

We also don't go far in considering the variation between fire districts. This is largely because the variation between districts is so great, likely due to factors including, but almost certainly not limited to levels of employment and prevalent industries. We do not explore piecing together this variance to compare across fire districts. Future analysis may see fit to explore using other variables such as employment and land uses to account for this variance.

Some of these limitations could potentially be overcome in future research if one were to use fully disaggregated data. This disaggregated data should include the specific time and location of calls to allow for exploring the impacts of time of day or land use and built environment on individual calls. As it stands, the flexibility of our analysis is limited by the level of detail we were able to obtain as a result of HIPAA protections (which required disaggregating to date and fire district to keep anonymize the data). Future research should build on this analysis by exploring additional factors that may play a role in the variation of 911 calls including controlling for other events and demographic variables that were outside the scope of this report.

311— Non-Emergency Services Analysis

Through our analysis, we find that there is no statistically significant relationship between the daily maximum temperature and call volumes across two datasets: a) all call volumes reported between 2018 and 2022 and b) all call volumes on non-heat days. We observe an almost negligible correlation between call volumes and temperature for extreme heat days, although the relationship is not strong enough to accurately support that there are fewer calls on heat days. On the contrary, we do find a statistically significant difference between call volumes on extreme heat days vs. non-heat days, when conducting a one-tailed t-test, and find that heat events on average experience higher call volumes than non-heat days.

Limitations

Although 311 service requests are readily publicly available, information requests submitted via phone are not. We do not analyze service request data, as none of the service request types are directly related to heat. We experienced some delays obtaining information request data, as the ITA's online server has been encountering capacity issues due to system updates for both residential users, and internal use

among 311 staff trying to access applications and reports. Even still, the data we received had limited geographic information as the current reporting procedure does not require callers to disclose personal addresses or neighborhood council district information.

Due to this data limitation, our analysis is at the citywide level and we cannot provide insight as to which areas within the City of Los Angeles experience the highest 311 call volumes during extreme heat days. However, we can provide some descriptive statistics for the data points that do contain neighborhood council districts, although this information may not be entirely representative of actual call volumes, as 64% of the data was excluded due to missing information.

RECOMMENDATIONS

Stemming from our findings, we compiled a list of recommendations for CEMO and the City's 911 and 311 systems, which should be considered and applied in conjunction with broader city agencies. CEMO's role in coordinating with other city agencies to respond to the climate emergency will prove to be an asset with interagency cooperation. With that said, it should be noted that recommendations for 911 and 311 systems assume a level of coordination on the part of the city to develop meaningful strategies in response to extreme heat.

Our recommendations for CEMO and the city as a whole, 911 (including LAFD, LAPD, and EMD), and 311 (ITA) are as follows:

Recommendations for CEMO and the broader city:

1. Develop proactive heat event outreach strategies embedded in the city's heat emergency response system to focus resources in areas and communities experiencing high excess calls, and the most number of heat events per year.
    a. Outreach can focus on spreading awareness of cooling centers and other resources in the hottest communities of the city (most notably the central San Fernando Valley).
2. Develop a consistent data reporting structure that can serve both internal and public facing purposes for monitoring emergency service during heat events.
    a. While managing and repeating this 911 analysis may be beyond the day to day scope of CEMO, this office can help the City build a repository of data to track and monitor heat events and emergency response for future research.
3. Validate using alternative data sources, such as Twitter and Google API, to assess and manage the needs of community members during heat and other climate emergencies.
4. Aggregate excess 911 calls to city council districts based upon the locations of fire stations to apply recommendations to political boundaries in addition to administrative boundaries.
    a. This will allow for local policy makers to act on the findings of this report to better allocate resources during periods of extreme heat.

5. Work with 311 to develop more detailed and centralized cooling center information.
    a. Existing 311 knowledge base information on cooling centers (or informal cooling locations) is limited, as evident by the public comments shared at the 2023 Los Angeles' Climate Equity Series public worship. Providing specific cooling center information would allow 311 to better connect people to cooling center resources.
6. Develop clear data collection and reporting procedures for the 311 call center to ensure that all data contains geographic information
    a. Neighborhood council district or census tract level would allow CEMO to identify specific communities experiencing the highest excess calls
    b. More specific geographies for both 911 and 311 calls, can be used to understand the city's current resource utilization during periods of heat and to develop strategies to better support communities that are most vulnerable to heat.
7. Create an event calendar to supplement heat calendar, and to control for confounding variables that can affect 911 and 311 call volumes during extreme heat events.
8. Create policy structures that consider heat as a chronic stressor and not just an "emergency" to support areas that are chronically overburdened with high heat.
9. Create more expansive definitions of heat emergency and heat warnings that use lower heat thresholds (90°F) than existing city policy (95°F in the LA Basin and 100°F in the Valleys and Mountains).
10. Prioritize and plan heat mitigation strategies for/with climate vulnerable populations.

Recommendations for 911 and EMD:

1. Set lower heat emergency thresholds and deploy more resources during "heat advisory" periods that may not meet official emergency thresholds.
2. Routinely track call volumes during periods of high heat to help identify areas needing more resources during and post heat events.
3. Share data regularly with CEMO to manage response to heat and other climate emergencies.
4. Invest in partnerships and "pre-emergency" resources in areas of the city that experience particularly high levels of heat.

    a. This should incorporate heat readiness outreach beyond social media and technology based outreach (which may leave out populations with less access to smartphones.
5. Ensure that all emergency call operators are familiar with signs or symptoms of heat illness to better identify heat related calls.

Recommendations for ITA on 311 system:

1. Update 311 recording procedures to:
    a. Include better service and information request coding that incorporates extreme climate events, specifically extreme heat related requests.
    b. Include consistent geographic information for all information requests submitted via phones.
2. Add a "cooling center" filter to the My311LA application to centralize all publicly-owned buildings that may function as a cooling center for users, instead of the current fragmented structure.
    a. Filters that may operate as a cooling center now include: Free Wi-Fi Hot Spots, Libraries, Museums, Public Computer Centers, Recreation Centers and Senior Centers.
3. Expand the number of services available through 311 to empower Angelenos with more convenient self-service options.
4. Develop a consistent community engagement plan across all agencies to increase its outreach, expand access, and improve usability.
5. Proactively survey the City's customers after a request has been closed and ask them to rate the quality of services.
6. Adopt lessons learned from its implementation of the current system to ensure a more successful project delivery.

CONCLUSION

911 and 311 systems provide a fundamental link between individuals and city services, and both are utilized during periods of extreme heat; however, ideally heat would not become an emergency for any individual. Developing more pathways to connect individuals with resources before they have an emergency related to heat is crucial for equitable heat response in Los Angeles.

This means that more energy must be aimed at providing resources to respond to heat, even on days that just meet a threshold of 90°F, and more energy must be directed towards proactively engaging in outreach and mitigation, including acting on the recommendations outlined in the other chapters of this report. Bus stop shade and cooling centers could both be key resources in mitigating and adapting to some of these issues.

Heat exposure and its impacts are complicated, and any mitigation strategies taken on by the City of LA as it responds to the Climate Emergency must be equally nuanced. Yet even today heat has a very real and describable health impact. The actions we don't take today will become calls for emergency services tomorrow.

ACKNOWLEDGEMENTS

We would first like to thank our supervisors—**Dr. Greg Pierce**, professor of urban planning at the UCLA Luskin School of Public Affairs, and **Dr. Ruth Engel**, project manager for environmental data science at UCLA Luskin Center for Innovation—for their endless guidance and support during each phase of our project. Secondly, we want to thank the following people, departments, and organizations for their invaluable insight and help acquiring data for which this project would not have been possible:

- **Donna Arrechea**, 311 Director, Information Technology Agency
- **Erin Coutts**, Executive Director, Los Angeles Regional Collaborative for Climate Action and Sustainability
- **Rebekah Guerra Day**, Management Analyst, Los Angeles Climate Emergency Mobilization Office (CEMO)
- **Anthony Guerrero**, Data Scientist, FireStat Section, Los Angeles Fire Department (LAFD)
- **Son Htet**, Senior Analyst, FireStat Section, LAFD
- **Jennifer Lazo**, Emergency Management Coordinator II, Emergency Management Department
- **Marta Segura**, Chief Safety Officer for City of Los Angeles & Director, CEMO

BUS SHELTERS FOR EQUITABLE EXTREME HEAT ADAPTATION

A Case Study of Los Angeles' Sidewalk and Transit Amenities Program (S.T.A.P.)

Abigail Koshollek
Nicole Matteson
Miguel Miguel
Jose Negrete

chapter 2

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EXECUTIVE SUMMARY

Introduction

As extreme heat events become more frequent and intense, cities must adapt to protect the health and safety of their residents without limiting their mobility. Some of these residents include transit dependent riders that utilize public bus service as their primary mode of transportation within the city. The health and comfort of passengers waiting for transit could be highly affected as extreme heat events intensify.[1] In 2018, the U.S. Global Change Research Program found that heat-related exposures of walking to and waiting for transit vary across neighborhoods in the City of Los Angeles based on local temperatures, transit service frequency, and the design of the street network.[2] Cities responded by increasing shade cover at bus stops because it can provide a high-impact way to improve the thermal comfort of transit riders.[3,4] This can be quite effective if done well; research on the increase of shade availability at bus stops demonstrated a reduction in the physiological equivalent temperature (PET) of up to 19°F.[5]

Despite bus shelters being essential public infrastructure for outdoor heat protection in Los Angeles, a recent study by UCLA Luskin School colleagues found that only 26% of bus stops operated by the Los Angeles County Metropolitan Transportation

1 USGCRP, 2018: Impacts, Risks, and Adaptation in the United States: Fourth National Climate Assessment, Volume II [Reidmiller, D.R., C.W. Avery, D.R. Easterling, K.E. Kunkel, K.L.M. Lewis, T.K. Maycock, and B.C. Stewart (eds.)]. U.S. Global Change Research Program, Washington, DC, USA, 1515 pp. doi: 10.7930/NCA4.2018.

2 Fraser, Andrew M., and Mikhail V. Chester. "Transit System Design and Vulnerability of Riders to Heat." Journal of Transport & Health, vol. 4, 2017, pp. 216–25, https://doi.org/10.1016/j.jth.2016.07.005.

3 Dzyuban, Yuliya, David M. Hondula, Paul J. Coseo, and Charles L. Redman. 2022. "Public Transit Infrastructure and Heat Perceptions in Hot and Dry Climates." International Journal of Biometeorology 66(2): 345–56.

4 Lanza, Kevin, and Casey P. Durand. 2021. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." International Journal of Environmental Research and Public Health 18(2): 463.

5 ibid.

Authority (METRO) currently have shelters.[6] Los Angeles is not alone in under-providing shelters; cities rarely if ever provide full bus stop shelter coverage. Part of this is due to a coordination problem: the City, not transit operators, decides where to place bus shelters, and land use restrictions complicate siting. Planning for the efficient and equitable allocation of bus shelters in Los Angeles is complex and multifaceted, but it is also a promising opportunity to provide heat relief for the City's vulnerable transit riders.

Motivation

The previous contract between the City of Los Angeles Bureau of Streets Services, colloquially known as StreetsLA, and JCDecaux fell short of its aim in providing new bus stop shelters across Los Angeles due to a complex approval process which hindered implementation.[7] This contract was recently replaced by the new Sidewalk and Transit Amenities Program (S.T.A.P.) stemming from StreetsLA's new contract with Tranzito/Vector LLC (Tranzito) which may last up to 20 years. The ambitious program aims to include heat adaptation in its allocation strategy for bus stop shelter placements and to ensure that 75% of bus riders in each City Council District will have access to a bus shelter.

In this chapter, our research answers the question:

Based on current evidence, does the City of Los Angeles' S.T.A.P. program appear to adequately and equitably provide extreme heat adaptation for transit riders?

6 Madeline Brozen, Chase Engelhardt, Eli Lipmen, . "Do LA Bus Riders Have Shelter from the Elements?" ArcGIS StoryMaps, February 17, 2023. https://storymaps.arcgis.com/stories/cf668947bf424ae886edc89f2004fbd6.

7 Lance Oishi and Paul Gomez, Conversation on S.T.A.P. Contract with Streets LA. (2023).

Analyses Conducted

CROSS-CITY COMPARISON

Reviewed and summarized how other cities are using bus shelters for extreme heat adaptation

BUS STOP FIELD VISITS

Observed the current conditions of bus stops in L.A. City Council districts 3, 5, and 14

INITIAL S.T.A.P. FUNCTIONING

Analyzed the S.T.A.P contract and listed the advantages and disadvantages of a Public-Private Partnership model for public infrastructure

CASE STUDY OF FIRST-YEAR S.T.A.P. ALLOCATIONS

Assessed the equitable performance of the 1st year S.T.A.P. shelter allocations and StreetsLA's priority ranking system in addressing the heat vulnerabilities and shelter needs of three L.A. City Council Districts

Findings

First, we find that the current version of the S.T.A.P program is limited in its potential to adequately or equitably provide heat relief for Los Angeles' transit riders. This is caused in part by the cost recovery aspect of the public-private partnership (PPP) model bus shelter siting relies on. While citywide bus shelter placement policy is not based on a commitment to shelters as truly public infrastructure for all, based on our review of other cities, we find Los Angeles is not unique in this regard. Historically, and across urban areas globally, we find that bus shelter placement policy is predominantly guided by the revenue potential of shelter advertisements and is often accomplished through PPPs for infrastructure. As in other cases, we find that the starting point for shelter investments in Los Angeles is predominantly guided by the revenue potential of shelter advertisements, followed by political considerations over geographic equity,

and lastly by bus stop use.[8] We find a similar pattern by looking at S.T.A.P. shelter placement decisions in 3 districts. Council Districts like Council District 3 and Council District 14 with high shelter needs based on heat and transit use are receiving far fewer new bus shelters under the S.T.A.P. for the first year compared to Council District 5, which has the highest allocation and highest median household income. .

Recommendations

Based on our analysis, we recommend the following actions for the City of Los Angeles:

1. **Reframe bus shelters as public infrastructure:** Bus shelters should be recognized as essential public infrastructure and supported by a more robust public investment strategy as opposed to a PPP model.
2. **Introduce a specific formula for bus stop allocation:** Develop a clear and transparent methodology for determining the placement of bus shelters. This formula should consider factors such as existing equity and heat metrics to ensure equitable distribution of shelters across different neighborhoods.
3. **Coordinate S.T.A.P. with other heat adaptation efforts:** Improve coordination between the Sidewalk and Transit Amenities Program (S.T.A.P.) and other heat adaptation initiatives in Los Angeles. This will ensure that bus shelter placements align with broader citywide strategies for mitigating the impacts of extreme heat.
4. **Consider an alternative to the current heat metric in S.T.A.P. allocation criteria:** Explore alternative criteria for allocating bus shelters in the S.T.A.P. program. One potential option is to incorporate Local Climate Zones (LCZs) as a heat metric, which can provide a more accurate assessment of local heat vulnerabilities and guide shelter placement decisions.
5. **Engage residents and local stakeholders in designing and siting bus shelters:** Community input and feedback helps to ensure that shelters meet the needs of the community and are located in convenient and accessible locations.

8 Law, Philip, and Brian D. Taylor. 2001. "Shelter from the Storm: Optimizing Distribution of Bus Stop Shelters in Los Angeles." Transportation Research Record: Journal of the Transportation Research Board 1753(1): 79–85.

INTRODUCTION

Extreme heat events refer to periods of exceptionally high temperatures that surpass the historical average for a region.[1] For the City of Los Angeles, these climate change-related events are intensifying such that historical temperatures which averaged in the mid-80s°F in some areas now experience at least 20 days a year with an average heat index of 90°F or higher.[2] In the absence of adaptation, Los Angeles residents may experience prolonged exposure as these events become more severe and frequent, which can lead to an increased risk of heat-related illnesses or injury. Heat exposure manifests differently throughout a city and makes one size fits all policy interventions difficult.

The Environmental Protection Agency (EPA) identified areas such as sidewalks, roads, and buildings as areas which are often unvegetated, hotter, and in need of shade.[3] Pavement and concrete absorb and radiate heat, exacerbating the urban heat island effect by increasing the ambient temperature especially in densely populated areas.[4] The exposure of streetscapes poses a particular hazard to transit riders who must wait outside and rely on publicly-installed bus shelters to seek thermal comfort. Bus shelters are typically semi-permanent structures located at bus stops with, at minimum, a bench and a roof to protect transit riders from inclement weather conditions. [5]

The forms of bus shelters vary based on the broader climate, built environment, and ideally are also customized to the needs of a city's residents. Some bus shelters include additional features as a way to improve the overall commuter experience. Additional features could include digital advertising displays, real-time transit information, and amenities like lighting or bicycle racks.[6] Robust research has been

1 United States Environmental Protection Agency . (n.d.). Extreme heat events . https://www.cdc.gov/climateandhealth/pubs/ClimateChangeandExtremeHeatEvents.pdf
2 "Hot Cities, Chilled Economies: Los Angeles, United States." Arsht-Rock, https://onebillionresilient.org/hot-cities-chilled-economies-los-angeles/. Accessed 21 May 2023.
3 US EPA, OAR. "Learn About Heat Islands." Overviews and Factsheets, June 17, 2014.
4 Cheela VRS, John M, Biswas W, Sarker P. Combating Urban Heat Island Effect—A Review of Reflective Pavements and Tree Shading Strategies. Buildings. 2021; 11(3):93. https://doi.org/10.3390/buildings11030093
5 Lanza K, Durand CP. Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership. Int J Environ Res Public Health. 2021 Jan 8;18(2):463.
6 ibid.

conducted to investigate how shade can reduce surface temperatures and improve thermal comfort during extreme heat events, and demonstrates protections of approximately 20-40°F less than peak temperatures.[7] Bus shelter provision presents a viable adaptation strategy for cities wanting to address increasing temperatures for residents who rely on this type of infrastructure when utilizing public transportation.

Unfortunately, the vast majority of transit riders face a significant challenge in accessing shelters to combat the heat, both in Los Angeles and beyond.[8] Accessibility is complicated due to lack of coordination between local government and transit agencies that service the City of Los Angeles which includes the city itself, the Bureau of Street Services (StreetsLA), Los Angeles County Metropolitan Transportation Authority (METRO) and Los Angeles Department of Transportation (LADOT), among others.[9] Furthermore, complications arise from land use restrictions and zoning regulations, which often render certain sidewalk widths inadequate or restrict the placement of shelters in specific areas.[10] It is important to note that the decision-making authority for shelter placement rests with the City rather than the transit operators. Consequently, the process of siting shelters becomes a complex matter entailing inherent tradeoffs. Limited funding, for instance, hampers the progress of shelter projects and impedes their implementation in underserved areas where they are most urgently needed.[11]

Interagency communication and collaboration between the City and its contracted partner are also complicated as both must comply with all federal, state and local laws regarding health and safety, labor and employment. Additionally, the S.T.A.P. contract is subject to the following laws: the Highway Beautification Act (HBA), the Patriot Act, the City of Los Angeles' Privacy Policy, the California Consumer Privacy Act

7 Akbari, Hashem, Dan M. Kurn, Sarah E. Bretz, and James W. Hanford. 1997. "Peak Power and Cooling Energy Savings of Shade Trees." Energy and Buildings 25(2): 139–48.
8 Miao, Qing, Eric W. Welch, and P.S. Sriraj. 2019. "Extreme Weather, Public Transport Ridership and Moderating Effect of Bus Stop Shelters." Journal of Transport Geography 74: 125–33.
9 Lance Oishi and Paul Gomez, Conversation on S.T.A.P. Contract with Streets LA. (2023). (2023).
10 Law, P., & Taylor, B. D. (2001). Shelter from the Storm: Optimizing Distribution of Bus Stop Shelters in Los Angeles. Transportation Research Record, 1753(1), 79–85.
11 Uranga, R. "Los Angeles Promises to Add Thousands of Bus Shelters." Los Angeles Times, 22 Sept. 2022, https://www.latimes.com/california/story/2022-09-22/los-angeles-thousands-of-bus-shelter.

and the City's Advertising Policy.[12] The challenge of interagency communication and collaboration arguably poses as one of the Achilles heels of systematic functioning of bus shelter programs.

BACKGROUND AND MOTIVATION

The equitable allocation of bus shelters in Los Angeles is a subject of significant debate and public engagement. The origins of this discussion are traced back to 1980, when LA METRO conducted a comprehensive bus stop facility study aimed at ensuring fair distribution of shelters across the City.[13] In subsequent years, the City of Los Angeles entered into contracts with JCDecaux in 1981 and 1982, tasking them with the installation, maintenance, and advertisement management of these shelters.[14] Both the private shelter provider and the City were primarily concerned with generating sufficient revenue from advertisements to cover the capital and maintenance expenses. As a result, their focus was directed towards placing shelters

12 The Highway Beautification Act (HBA) of 1965 was a law motivated by then president Lyndon B. Johnson to control outdoor advertising along national highways. California's statewide transportation agency, Caltrans, has jurisdiction over advertising, permitting and control along the Interstate and state highways in California. Should any S.T.A.P. Elements be located in areas which fall under Caltrans' jurisdiction, the Contractor is responsible for obtaining and paying for any permits that are required by Caltrans. The Patriot Act of 2001 was enacted to "deter and punish terrorist acts in the United States and around the world, to enhance law enforcement investigatory tools, and other purposes". The Patriot Act applies to this contract by requiring that the Contractor nor any subcontractors are listed on any lists managed by the Office of Foreign Assets Control of the US Department of the Treasury, the Bureau of Industry and Security of the US Department of Commerce. The City of Los Angeles' Privacy Policy discusses how and for what purposes both anonymous and personally identifiable information is used by the City.# The contract states that any data collected under the S.T.A.P. program will only be used exclusively for the delivery and/or improvement of City services, and that it is the sole property of the City. The California Consumer Privacy Act (CCPA) of 2018 was designed to increase consumer's control over their personal data being collected and used by businesses. The CCPA also specifies guidelines for how to implement the law. Of particular importance to this contract, Tranzito is required to respond to public requests for data that is collected under the S.T.A.P. project. The City of Los Angeles' Advertising Policy controls advertisement content that is placed on City-owned structures, facilities and Public Rights-of-Way. Acceptable advertisement content is restricted to commercial purposes such as "advertising that promotes the sale of goods and services or events promoting goods and services".

13 Law, Philip, and Brian D. Taylor. 2001. "Shelter from the Storm: Optimizing Distribution of Bus Stop Shelters in Los Angeles." Transportation Research Record: Journal of the Transportation Research Board 1753(1): 79–85.

14 ibid

in wealthier areas that offered greater potential for advertising revenue.[15] Despite their efforts, the revenue generated from these bus shelters in the form of advertisement revenue for the City amounted to just under $1 million annually.[16] Additionally, research uncovered a striking revelation: not a single one of the 26 bus shelters was allocated to bus stops with the highest average daily boardings.[17] In contrast, transit operators generally prioritize improving transit ridership, resulting in shelter placement in geographies with the highest ridership.[18]

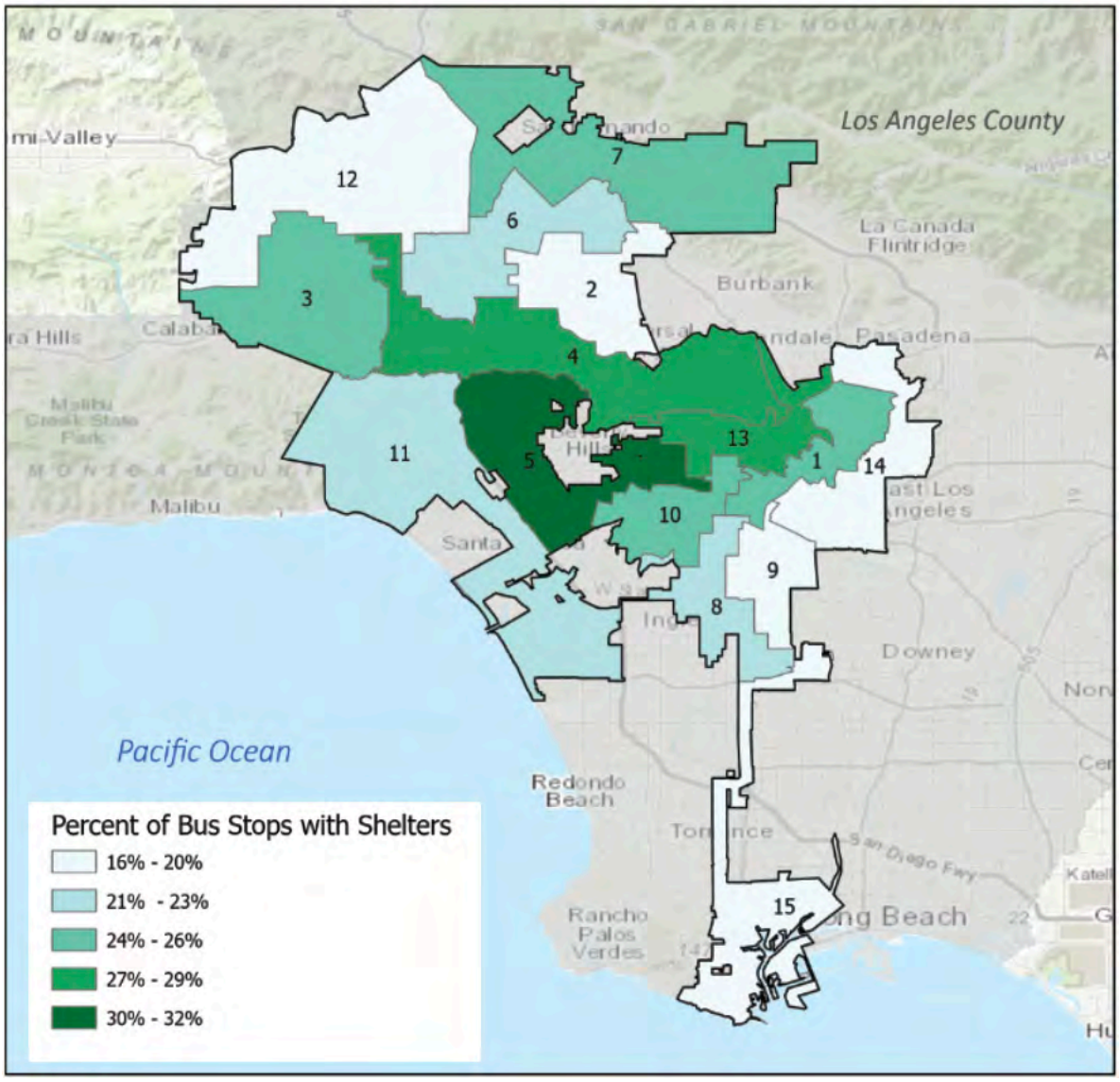
The City of Los Angeles recently shifted its attention towards the issue of extreme heat, adding another crucial element to consider when allocating bus shelters. As individuals traverse the urban landscape, certain residents, known as transit-dependent riders, rely heavily on public transportation as their primary mode of mobility. However, this dependence on transit poses a potential risk, as these riders often find themselves waiting outside and depend on publicly-installed bus shelters to seek refuge from the heat. In 2018, the U.S. Global Change Research Program identified that heat-related exposures of walking to and waiting for transit vary across neighborhoods in the City of Los Angeles based on local temperatures, transit service frequency, and the design of the street network..[19] Heat exposure and vulnerability throughout the City requires thoughtful and research-based interventions to address inequities between communities.

A 2023 study conducted by the UCLA Lewis Center for Regional Policy Studies analyzed the spatial distribution of METRO bus shelters in Los Angeles County. Of the 10,527 bus stops examined in their study, only 26% were equipped with a shelter (refer to Figure 1).[20] Bus shelter placements are primarily driven by the revenue generated from advertising boards installed alongside benches or shelters.[21] This study highlights a crucial issue: municipalities, rather than local transit operators, bear the responsibility for financing and operating public bus shelter infrastructure, leading to a complex distribution of resources. While municipalities have the authority to determine shelter

15 ibid
16 ibid
17 ibid
18 ibid
19 Fraser, Andrew M., and Mikhail V. Chester. "Transit System Design and Vulnerability of Riders to Heat." Journal of Transport & Health, vol. 4, 2017, pp. 216–25, https://doi.org/10.1016/j.jth.2016.07.005.
20 Lipmen, Madeline Brozen, Chase Engelhardt, Eli. "Do LA Bus Riders Have Shelter from the Elements?" ArcGIS StoryMaps, February 17, 2023. https://storymaps.arcgis.com/stories/cf668947bf424ae886edc89f2004fbd6.
21 ibid

placement based on their ownership of the public right-of-way, this often means that revenue generation takes precedence over vital considerations like ridership and the urgent need to address extreme heat exposure. The findings of this study shed light on a systemic problem that demands immediate attention and action.

Fig 1. Current Bus Shelter Availability in the City of Los Angeles by Council District



Adopted from UCLA Lewis Center for Regional Policy Studies.

Municipalities typically adopt a PPP model for the implementation of bus shelters, wherein government agencies collaborate with private sector companies responsible for financing, constructing, and operating such projects. Previously, the City of Los Angeles partnered with the global contractor OUTFRONT JCDecaux, LLC (OFMJCD), as part of the Coordinated Street Furniture Program (CSFP), which commenced in 2001 as a self-funded and self-sustaining initiative. To sustain the program, contracts were established with various advertisers who paid to display their advertisements on bus shelters and benches. A total of 1,884 shelters with litter receptacles were erected through this agreement. Under the CSFP, the City expected to receive a minimum payment of $150 million in advertising revenue over the course of the 20-year contract with JCDecaux.[22] However, the City's share of revenue depended on the funding it allocated for capital expenditures related to transit shelter construction and maintenance.[23] As of late November of 2021, the revenue generated for the City through the CSFP amounted to only $78.5 million.[24]

In response to the expiration of the CSFP in 2021, StreetsLA developed a new transit shelter program called the Sidewalk and Transit Amenities Program (S.T.A.P.). This program establishes a fresh contract between StreetsLA and Tranzito/Vector LLC (Tranzito) that could extend for up to 20 years. The primary objective of S.T.A.P. is to enhance bus stop shelter placements, including by incorporating heat adaptation as one of its key metrics. It also aims to ensure that 75% of bus riders in each city Council District have access to a bus shelter, while focusing on refurbishing existing shelters. The projected revenue for the program's first 10 years of operation is $638.8 million. Notably, the new revenue share agreement will enable the City of Los Angeles to earn a significantly higher percentage (60.5%) of advertising revenue, contingent upon the city covering the capital costs associated with S.T.A.P.[25]

Sidewalk and Transit Amenities Program (S.T.A.P.) Prioritization Methodology

The primary objective of the S.T.A.P. is to significantly expand the Citywide bus shelter inventory from the current 1,737 shelters to a total of 3,000 shelters. To effectively

22 Bureau of Street Services, "Department of Public Works."
23 Lance Oishi and Paul Gomez, Conversation on S.T.A.P. Contract with Streets LA. (2023).
24 Ronald F. Deaton, "Coordinated Street Furniture Program Selection of Proposer."
25 City of Los Angeles. "Contract between City of Los Angeles and Tranzito/Vector, LLC For Sidewalk And Transit Amenities Program (S.T.A.P.)," pg. A-8 thru A-11, April 28, 2022.

determine the most deserving bus stops for new shelter installations or refurbishment of existing ones, a comprehensive priority system has been developed. StreetsLA designed a multi-tiered prioritization framework that systematically evaluates stops based on five distinct categories, each with its own set of definitions and specific metrics (refer to Figure 3):

Fig 2: S.T.A.P. Ranking Criteria

HEAT

Projected average maximum temperature during Heat Health Events (HHE) as calculated by CHAT. Ranked in the following order: <=93.71 °F; 93.72-98.72 °F; 98.73-103.69 °F; 103.70-104.86 °F; or between 104.87-107.02 °F

RIDERSHIP

Average weekday boardings value less than, greater than, or equal to 100

EQUITY FOCUSED COMMUNITIES

Identification of a bus stop located within a Los Angeles METRO Equity Focus Community (EFC). EFC's were calculated based upon minority populations, low-income households, and zero-vehicle households.

KEY DESTINATIONS

Number of key destinations and trip generators within a 0.25 mile radius of the bus stop

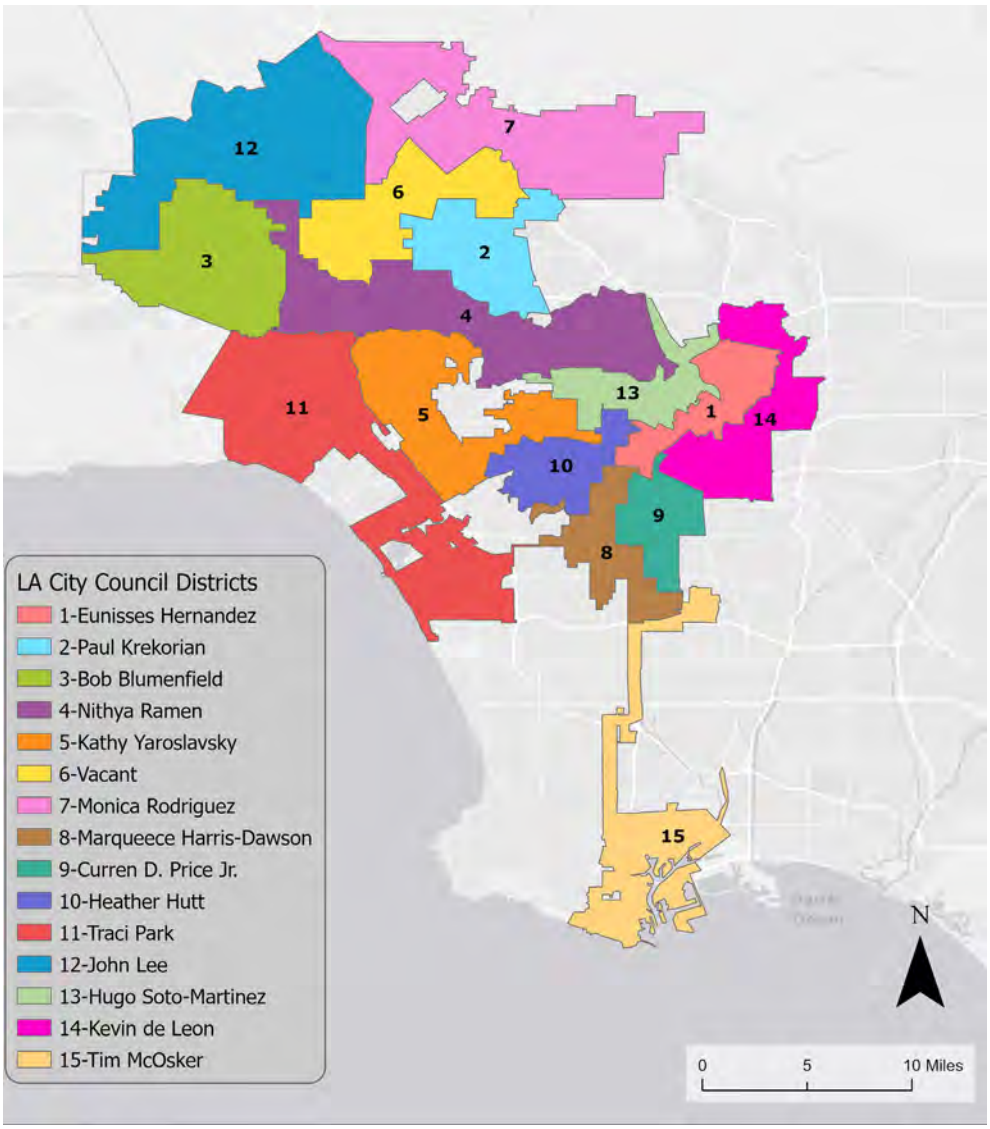
LONG WAIT TIMES/INFREQUENT SERVICE

A bus stop either does or does not service a bus route with base frequency of greater than or equal to 30 minutes

To effectively prioritize bus stop investments, StreetsLA has developed a comprehensive scoring system as part of their multi-tiered prioritization framework that assigns a specific score to each variable, resulting in a maximum score of 25 for each stop. This scoring system enables the creation of priority tiers for investment. Bus stops with the highest scores are classified as very high priority, followed by three subsequent priority levels: high, moderate, and low. Using this ranking, StreetsLA generates a list of proposed shelter installations and revitalizations for each of the

15 council districts that make up the City of Los Angeles. These districts encompass multiple neighborhoods and diverse populations (refer to Figure 4 for an overview). Each council district is represented by an elected official who holds voting power in deciding on proposed policies and financial matters for the City. The proposed list of shelters is then presented to the City Council members, who possess the ultimate authority to approve or reject the proposed stops within their respective council districts. The process is designed to ensure that the decisions align with the needs and priorities of each district and allows for local representation in determining the allocation of resources.

Fig 3: Council District Representatives Map



Data Source: LA City Open Data Portal January 2022

Our Study Aim

The ambitious S.T.A.P. program has the potential to provide a significant increase in heat relief for Los Angeles transit riders, but it must be implemented equitably. Given that stops which have the greatest revenue potential are often found in wealthier areas that often have greater resources to invest in bus shelters, a PPP model such as S.T.A.P. must demonstrate how it can prioritize equity in practice.[26] Moreover, current inequitable trends are a cause of inadequate community engagement and limited representation from transit users that are predominantly people of color from low-income neighborhoods with low car ownership rates.[27] When the voices and needs of underserved neighborhoods are not adequately considered, the allocation of resources tends to favor areas with more political influence and economic power. Without access to sheltered bus stops, transit-dependent riders are subjected to harsh weather conditions, including extreme heat, which places a higher risk of adverse health effects.[28]

To inform equitable and heat-focused rollout of this new street furniture program, our study in this chapter aims to answer the following overarching question: **based on current evidence, does the City of Los Angeles' S.T.A.P. program appear to be on the right trajectory to adequately and equitably provide extreme heat adaptation for transit riders?**

We provide initial answers to this question by conducting an analysis of the S.T.A.P. contract, cross-city comparison approach to heat adaptation planning in terms of transit shelters, and evaluate the current state of LA's bus stops through bus stop field visits. These analyses give further context on the patterns of equitable bus shelter allocation, and help us understand the positive and negative outcomes of a PPP like S.T.A.P. in providing equitable and essential public street furniture.

We then conduct a case study of three LA Council Districts to provide context and comparatively analyze the allocation of first-year proposed S.T.A.P shelters. We identify

26 "The Unequal Commute." Urban Institute, 6 Oct. 2020, https://www.urban.org/features/unequal-commute.
27 METRO, L. A. "Results of Our 2022 Customer Experience Survey." The Source, 27 Oct. 2022, https://thesource.metro.net/2022/10/27/results-of-our-2022-customer-experience-survey/.
28 Chen, Anna. "What It Takes to Get a Bus Shelter Installed." The Source, 16 Dec. 2019, https://thesource.metro.net/2019/12/16/what-it-takes-to-get-a-bus-shelter-installed/

trends associated with shelter distribution and the unique vulnerabilities of the council districts. Potential recommended policy interventions, including changes to the city's approach and emphasis on contracting, for equitable transit shelter distribution are discussed in greater detail in the report's conclusion.

LITERATURE REVIEW

First, we contextualize our analysis of the City of LA by conducting a broader literature review discussing the latest research related to extreme heat, bus riders and bus shelters. Each topic is broken into subsections followed by a summary of the research, its implications, and how it has shaped our work.

Rising Temperatures, Human Health, and the Role of Adaptation

Across the Los Angeles region, temperatures are rising. The Los Angeles County Department of Public Health reports "[C]oastal areas and central Los Angeles will experience three times more days of temperatures over 95°F."[29] Researchers acknowledge that in hot and dry places like Los Angeles, both macro and micro strategies are needed in order to ensure thermal comfort and functional social service systems. Macro strategies are those which aim to reduce overall air temperature across the city, whereas micro strategies introduce vital infrastructure to provide heat relief in a particular place.[30]

Extreme Heat and Bus Riders

Severe weather events are well documented in the literature to have negative impacts on transit ridership. The level of impact is largely based on the respective type of extreme weather event.[31, 32, 33] Extreme heat in particular has a significant negative

29 "Extreme Heat and Climate Change | Los Angeles County Department of Public Health - Environmental Health."

30 Bandurski et al., "The Green Structure for Outdoor Places in Dry, Hot Regions and Seasons—Providing Human Thermal Comfort in Sustainable Cities."

31 Lanza, Kevin, and Casey P. Durand. 2021. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." International Journal of Environmental Research and Public Health 18(2): 463.

32 Arana, P., Cabezudo, S., Peñalba, M., 2014. Influence of weather conditions on transit ridership: a statistical study using data from Smartcards. Transp. Res. A: Policy Pract. 59, 1–12.

33 Tao, S., Corcoran, J., Hickman, M., Stimson, R., 2016. The influence of weather on local geographical patterns of bus usage. J. Transp. Geogr. 54, 66–80. TCRP, 2013. Transit Capacity and Quality of Service Manual, Third Edition Transportation Cooperative Research Program, Washington, D.C.

impact on bus ridership.[34, 35] One study in Lane County, Oregon found that bus ridership decreased by 0.3% when the daily maximum air temperature met or exceeded 84.2°F.[36] While 0.3% does not seem like a lot, this ridership loss can have significant impacts to revenue generation which supports and maintains the transportation network.[37] For example, a study found that ridership loss due to summer rains could lead to a $0.6 million in revenue losses for Chicago Transit Authority.[38] Providing relief from heat will become more crucial for cities as temperatures increase in the coming decades in order to prevent ridership loss.

The amount of time a bus rider is exposed to potentially dangerous heat is dependent on how they access the bus stop, the distance between their place of origin and the bus stop and the amount of time they wait at the bus stop.[39] In the United States, 81% of all bus transit trips begin with riders walking to the bus stop with an average walking time of 7.1 minutes.[40] The amount of time a bus rider waits at the stop for their bus to arrive, and thus how long they are exposed to outdoor conditions, is dependent on service frequency, dependability and rider knowledge of the bus schedule.[41] A study found that the average wait time at LA METRO stops is 11.2 minutes and the average walking time to bus stops is 4.7 minutes.[42] This means that bus transit users could be exposed to potentially dangerous heat for an average total of 15.9 minutes. However, this number only considers buses that arrive on time. Actual lengths of exposure may be greater. According to a 2015 study, about 20% of METRO buses arrive at least five minutes late.[43]

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34 Rosenthal, Noam et al. 2022. "Adaptive Transit Scheduling to Reduce Rider Vulnerability during Heatwaves." Sustainable and Resilient Infrastructure 7(6): 744–55.

35 Lanza, Kevin, and Casey P. Durand. 2021. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." International Journal of Environmental Research and Public Health 18(2): 463.

36 ibid

37 Singhal, Abhishek, Camille Kamga, and Anil Yazici. 2014. "Impact of Weather on Urban Transit Ridership." Transportation Research Part A: Policy and Practice 69: 379–91.

38 Miao, Qing, Eric W. Welch, and P.S. Sriraj. 2019. "Extreme Weather, Public Transport Ridership and Moderating Effect of Bus Stop Shelters." Journal of Transport Geography 74: 125–33.

39 Fraser, Andrew M., and Mikhail V. Chester. 2017. "Transit System Design and Vulnerability of Riders to Heat." Journal of Transport & Health 4: 216–25.

40 ibid

41 ibid

42 ibid

43 Mendelson, Aaron. 2015. "How Late Are Los Angeles Buses and Trains? Depends Which Line You're Riding." LAist - NPR News for Southern California - 89.3 FM. https://www.kpcc.org/2015-02-19/how-late-are-los-angeles-buses-and-trains-depends (May 21, 2023).

Interventions to Mitigate the Impact of Extreme Heat on Bus Riders

There are a number of interventions aimed at reducing transit riders' vulnerability to extreme heat. The first and perhaps most direct intervention is increasing shade cover at bus stations. Bus shelters, artificial shade structures, and street trees are all well-researched interventions that can improve the thermal comfort and transit experience for transit riders.[44,45] One study found that shade efficiently reduced the physiological equivalent temperature (PET) of a bus stop by 19°F.[46]

Research is mixed on whether overall ridership rates benefit from bus shelters as a mitigation strategy for extreme heat. A study in Salt Lake City, Utah found that bus stops with shelters experienced higher ridership during days of extreme heat than bus stops without shelters ($p<0.01$).[47,48] However, a study in Austin, Texas found no moderating effect of bus shelters in preventing ridership loss during days of extreme heat but found that tree canopy cover had a stronger relationship ($p<0.001$).[49] The authors suggest that the lack of ridership loss by adding bus shelters could be due to transit dependent riders who often have no other means of transportation and therefore must endure whatever weather conditions exist.[50] Another potential explanation is the quality of the bus shelters and their cooling capacity. The design of bus shelters can affect their cooling capacity. Discussion of shelter design is discussed in greater depth in the following section of our literature review.

Reducing time spent waiting for the bus is also an essential component for improving the thermal comfort of transit riders. In Los Angeles, LA METRO designates service frequencies dependent on estimates of demand and passenger capacities which follow a semidiurnal trend with two peaks in the day that correspond to morning

44 Dzyuban, Yuliya, David M. Hondula, Paul J. Coseo, and Charles L. Redman. 2022. "Public Transit Infrastructure and Heat Perceptions in Hot and Dry Climates." International Journal of Biometeorology 66(2): 345–56.
45 Lanza, Kevin, and Casey P. Durand. 2021. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." International Journal of Environmental Research and Public Health 18(2): 463.
46 ibid
47 ibid
48 Miao, Qing, Eric W. Welch, and P.S. Sriraj. 2019. "Extreme Weather, Public Transport Ridership and Moderating Effect of Bus Stop Shelters." Journal of Transport Geography 74: 125–33.
49 ibid
50 ibid

and afternoon rush hours.[51] Time spent waiting for transit is inversely related to bus frequencies; with longer headways in between buses, riders spend longer amounts of time waiting at the bus stop.[52] Periods of typically lower service in the afternoons between 1 pm to 3 pm are also some of the hottest hours of the day.[53] Studies show that adjusting transit schedules, routes, and/or service frequencies during days of extreme heat reduces transit riders' exposure to potentially unsafe outdoor conditions.[54,55] Challenges with implementing this type of intervention include planning around the variability of extreme heat, budgetary restraints, and fleet capacity.[56] Most municipal transportation departments are not profit-driven and therefore lack the liquid resources to pay for additional buses that are only intended for use on extreme heat days.[57] Additionally, cities need to inform transit riders well in advance of schedule changes in order to avoid causing undue stress/confusion.[58]

Regardless of their cooling capacity, well designed bus shelters provide other benefits. Updating bus stop amenities has been shown to attract more riders, thereby increasing transit ridership.[59] Bus shelters also reduce transit riders' perceived wait time: riders report longer wait times at stops without shelters.[60] Due to the challenges associated with adjusting bus schedules as a means to reduce transit riders' exposure to extreme heat and the indirect benefits of increasing shade availability at bus stops, it is clear that cities have a large incentive to invest in their bus shelter infrastructure.

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51 Fraser, Andrew M., and Mikhail V. Chester. 2017. "Transit Planning and Climate Change: Reducing Rider's Vulnerability to Heat." In International Conference on Sustainable Infrastructure 2017, New York, New York: American Society of Civil Engineers, 456–64. http://ascelibrary.org/doi/10.1061/9780784481202.043 (February 4, 2023).

52 ibid

53 ibid

54 Fraser, Andrew M., and Mikhail V. Chester. 2017. "Transit Planning and Climate Change: Reducing Rider's Vulnerability to Heat." In International Conference on Sustainable Infrastructure 2017, New York, New York: American Society of Civil Engineers, 456–64. http://ascelibrary.org/doi/10.1061/9780784481202.043 (February 4, 2023).

55 Rosenthal, Noam et al. 2022. "Adaptive Transit Scheduling to Reduce Rider Vulnerability during Heatwaves." Sustainable and Resilient Infrastructure 7(6): 744–55.

56 ibid

57 ibid

58 ibid

59 Kim, Ja Young, Keith Bartholomew, and Reid Ewing. 2020. "Another One Rides the Bus? The Connections between Bus Stop Amenities, Bus Ridership, and ADA Paratransit Demand." Transportation Research Part A: Policy and Practice 135: 280–88.

60 Eo, J. (2018). Analyzing How Bus Ridership is Influenced by Physical Environments, Crime, and Collision Adjacent to Bus Stops.

Bus Shelter Design: Functional Features Matter for Thermal Comfort & Other Outcomes

While this project does not focus in detail on the design elements of Tranzito's bus shelters, we discuss at a high level the implications of different shelter design elements. The design of a shade structure is equally important and often just as complicated as siting the shelter. This is because the design of bus shelters and shade structures must consider an assortment of socio-spatial and topographic features. The main function of a bus shelter is to provide relief from the elements, but many shelters also provide information on transit routes and schedules and a place to rest while waiting for the bus.[61] A few guiding principles for shelter design are safety, accessibility, and protection from the sun, wind, and rain.[62] Shelter users report feeling safer when the shelter is well-lit and they have an unobstructed view of their surroundings.[63] Shelters also need to consider disabled and older adults' ability to use the structure in a safe and equitable manner.

Shelters must be designed in such a way that provides shade during the hottest times of the day for heat relief. As the angle of the sun shifts across the day, the shaded area moves. It is important to consider when and where shade should be available to provide transit riders with the most relief. It is also important to choose materials that will not absorb and reradiate sunlight, thereby increasing heat in their vicinity.[64] Bus shelters need to complement the physical orientation of the local built environment in order to provide high-quality shade. Bus stops that are already shaded by nearby trees or buildings may not require as much investment in shade production as others. A homogenous, "one-size-fits-all" approach to shelter design can fail to address the key concerns of transit riders, lack consideration of local context, and risk the efficacy of bus shelters and shade structures.

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61 ibid

62 Law, Philip, and Brian D. Taylor. 2001. "Shelter from the Storm: Optimizing Distribution of Bus Stop Shelters in Los Angeles." Transportation Research Record 1753(1): 79–85.

63 ibid

64 Colter, K.R., A.C. Middel, and C.A. Martin. 2019. "Effects of Natural and Artificial Shade on Human Thermal Comfort in Residential Neighborhood Parks of Phoenix, Arizona, USA." Urban Forestry & Urban Greening 44:

Summary of Past Scholarship

It is clear from the literature that extreme heat and associated adaptation interventions, including bus shelter siting and design, are complex and multifaceted. In an attempt to contribute to broader research regarding the role of bus shelters in equitable extreme heat adaptation, our study examines initial evidence on the efficacy of LA's new bus shelter allocation procedure which centers extreme heat and equity. Our research analyzes the recent shelter improvement contract and compares Los Angeles' efforts to other cities in the framework of how PPPs support public infrastructure expectations. Our findings also shed a light on contemporary opportunities and challenges for heat elements of bus shelter allocation programs beyond Los Angeles.

DATA AND METHODS

StreetsLA evaluates each bus stop using their own methodology and assigns a level of priority. However, it is unclear exactly how it decides which bus stops should be proposed first to the City Council. In short, the missing link is easily accessible, and public information on how StreetsLA selects which stops should receive a shelter first once they are ranked. The question then becomes: *What appears to influence their decision?* Are the results of the initial selection process equitable? A clear limitation of this approach is that the analysis of the long-term contract occurred during the 1st year of the S.T.A.P. program. There is still time for the program to evolve in its implementation, making the contract agreement design and initial stop selection analysis less relevant over time.

Our research uses multiple methods to provide a holistic case study to begin to understand if the City of Los Angeles' S.T.A.P. program adequately and equitably provides extreme heat adaptation for transit riders. The case study approach consists of distinct but complementary qualitative and quantitative analyses. For clarity's sake, we break the methodology description, analysis, and findings into two overarching sections: one for qualitative and one for quantitative analyses.

We begin with a qualitative cross-city comparison of heat-bus shelter planning in other cities, evaluate bus stops and shelters along LA METRO bus route(s) through bus stop field visits, and conduct an analysis of the initial S.T.A.P contract functioning. Our approach allows us to characterize how other cities are financing their bus shelter plans and placements in the context of extreme heat adaptation in order to provide a contextual understanding of the current conditions of bus stops in Los Angeles and the implications of the S.T.A.P. contract's 1st-year placements.

Qualitative Methodology

The qualitative data for our analysis was compiled using three primary data collection efforts: secondary documentation on and synthesis of heat-bus shelter planning by other cities, bus stop field visits, and analysis of the initial S.T.A.P contract functioning. A limitation of this approach was that there are very few case studies of heat action plans by cities similar in scale to LA across the U.S. and internationally that reference bus shelter plans. As a result, only a few municipalities have heat action plans that include interventions at bus stop shelters to consider for our study.

The bus stop field visits consisted of walking L.A METRO bus routes to collect primary data on the condition of the bus stops in the Council District (CD) of focus for our case study. The field visits occurred in February 2023 between the hours of 12-4 pm during the cold season in L.A. The team utilized our quantitative data to select Council District 14 as our observation site for primary data collection. LA METRO has approximately 12,088 bus stops across 121 total bus routes as of October 2022. The following LA METRO bus lines were selected for direct observation: 33, 51, and 81. During bus stop field visits, the team took note if bus stops had benches, shade, and shelter structures to collect data on which bus stops in key bus lines needed street furniture and/or bus shelters. Two team members conducted observations at 64 bus stops along LA METRO bus lines 33, 51, and 81. LA METRO bus line 33 has a total of 81 bus stops, bus line 51 has 33, and bus line 81 has a total of 15 bus stops for a total of 129. The observations occurred over a 4-hour period from 12-4 pm on February 16, 2023, beginning from bus route 33 from Main Street in DTLA bordered by the 101 freeway to Venice Blvd bordered by the 10 Freeway to Figueroa, bus route 81 from San Pedro Street to Slauson Avenue, and bus route 51 from North Figueroa Street to the 101 as our observation borders. The data was used to identify how many bus stops were missing street furniture along the sample LA METRO routes in Council District 14.

Lastly, we undertook a primary analysis of the initial S.T.A.P contract functioning. The analysis was done in order to compare the City's new contract with Tranzito/ Vector LLC to its previous contract with JCDecaux and to analyze whether or not the contract lives up to its promises of equitable distribution of shade shelters.

Quantitative Methodology

The findings from this analysis are further evaluated through a quantitative analysis of three city council districts. Our case study districts represent different levels of projected mid-century maximum temperatures and current transit shelter inventory to establish differences in the need for heat adaptation. We then calculate summary statistics for the council districts based on the following variables:

- Projected maximum temperatures between 2021-2040
- Current percent of LA METRO bus stops with shelters
- Count of S.T.A.P. very high and low priority stops
- How much time riders wait at METRO bus stops
- Overall bus stop activity (the sum of boardings and off-boardings of each METRO stop in the district)
- Commute trips by bus
- Average median household income by Council District
- Council District population

The total number of proposed first year S.T.A.P transit shelters in each district are then assessed in relation to these variables to discern heat and equity allocation patterns across each district.

QUALITATIVE ANALYSIS AND FINDINGS

Cross-City Comparison, Stop Observations, and Contract Analysis

In this section, we present our findings on a comparative cross-city bus-heat shelter plan, field observations of our council district of focus, and an analysis of the contract.

1. Cross-City Comparison

Cities across the globe are increasingly planning for extreme heat. Of the heat adaptation plans that are starting to emerge, however, only a few appear to incorporate bus shelter plans for heat adaptation. Here we analyze climatically-varied jurisdictions of Boston, Massachusetts, Miami-Dade County, Phoenix, Arizona, Singapore, and Dubai in comparison to the City of Los Angeles. These jurisdictions have their own set of criteria for bus stop shelter placements that focus on local microclimatic conditions. Notably, each of their bus shelter plans are structured on a PPP model of bus shelter placement that is dependent on advertising revenue, a phenomenon which we discuss and critique below. Table 1 summarizes key comparison results.

Table 1: Heat-Bus Shelter Plans in Comparator Cities

City	Agency	Public-Private Partnership (PPP)	Action Plan(s)	Bus Shelter Placement Criteria
Los Angeles, CA	StreetsLA	Tranzito/Vector	S.T.A.P. Contract, Heat Action Plan currently in development	High Transit Ridership,Heat, LA METRO EFC,Proximity to Trip Generator, Key Destinations, and Service Facilities, and Low Frequency" Bus Route
Boston, MA	Public Works Department	JC Decaux (until 2026)	Heat Resilience Solutions, 2021	Low tree cover areas,major streets with heavy pedestrian use and high temperatures that link with local destinations to place shaded bus stops
Miami-Dade County, FL	Department of Transportation and Public Works, Office of Heat Response & Mitigation	Outfront Media	Heat Action Plan, 2021	Highest urban heat island effect,lowest tree canopy, high pedestrian and transit use.
Phoenix, AZ	Public Transit Department	Lamar Advertising	Climate Action Plan, 2021, T2050 Plan	High ridership, transfers, Population density, and Proximity to activity centers
Singapore	Land Transportation Authority	Innosparks of ST Engineering Open Lab	Cooling Singapore Initiatives, 2022 Land Transit Master Plan	Urban Heat Islands
Dubai, UAE	Roads and Transport Authority	Right Angle Media	Climate Change Adaptation Strategy	4 Hotspots across Dubai.

Domestic City Comparisons

Miami-Dade County was the first metropolitan area in the world to appoint a Chief Heat Officer tasked with coordinating efforts to help vulnerable communities prepare for extreme heat.[65] Miami-Dade worked in partnership with Florida International University (FIU) and the University of Miami to create research-backed extreme heat policies. One such program is FIU's Shading Dade Initiative which informs tree planting in high pedestrian traffic areas and bus stops as part of their 2022 Extreme Heat Action Plan.[66]

Miami-Dade aims to address historical and current inequities affecting vulnerable communities from extreme heat. Under the Shading initiative, 40 sensors will be placed at 20 bus stops with shade and 20 without shade to collect data on microclimatic conditions across the stops.[67] Additionally, Miami-Dade County recently launched the Department of Transportation and Public Works' new Bus Passenger Shelter Program to improve transit riders' bus experiences while addressing extreme heat risks by May 31, 2035. Miami-Dade County appears to differ significantly from the City of L.A. in terms of the nature of agencies involved and interagency collaboration. Heat adaptation is being implemented in a collaborative effort between Miami-Dade County and jurisdictions within the County.

As part of Action 14 of the Extreme Heat Action Plan, Miami-Dade County has developed a set of criteria to identify priority bus stops and pedestrian walkways. They consider stops that have:

- The highest heat island effect
- The lowest current tree canopy
- High pedestrian and transit use

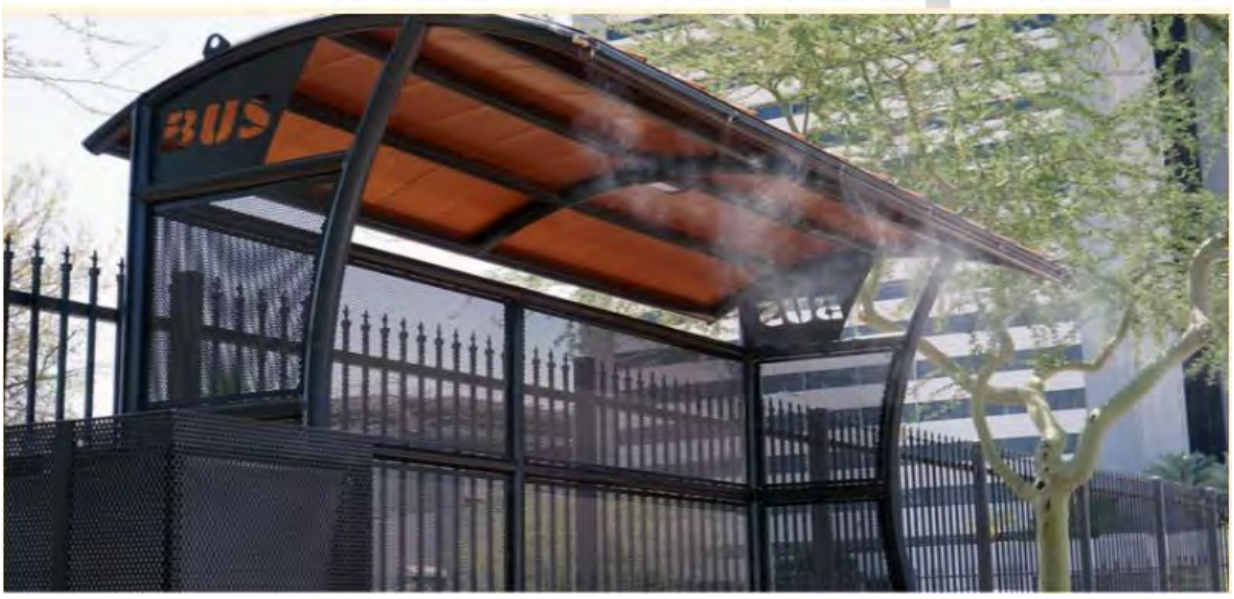
Additionally, Action 6 of Goal 1 of its Extreme Heat Action Plan states that the county will augment these efforts by leveraging the urban heat research group in collaboration with community organizations for continued learning of heat mitigation

65 Dade County mayor Daniella Levine cava announces first-ever chief heat officer. Miami. (2021, April 30). Retrieved March 21, 2023
66 Miami-Dade County Extreme Heat Action Plan. (2022). Retrieved March 22, 2023
67 ibid

efforts through data collection to inform bus stop shelter replacements.

The City of Phoenix, Arizona is also at the forefront of addressing extreme heat. In its efforts to address heat inequities, Phoenix adopted several programs that aim to improve transit riders' experience at bus stops. Implemented in 2018, the Misted Bus Shelter received positive reviews from the public for helping cool transit riders waiting in high heat (see Figure 4).[68] Unlike Los Angeles, Phoenix demonstrated greater preparedness in heat adaptation measures in its smaller transit system. Currently, 2,680 (70%) of Phoenix's 4,050 bus stops already have shelters under the City of Phoenix's Climate Adaptation Plan of 2021. The Climate Adaptation Plan aims to provide shade structures at all 4,050 bus stops in the City to achieve climate equity. Phoenix uses high ridership, transfers, population density, and proximity to activity centers to prioritize the allocation of its new bus shelters.

Fig 4: Misted Bus Shelter in Phoenix, Arizona



Finally, in terms of U.S. cities, the City of Boston, in collaboration with community partners, created its Heat Resilience Plan in 2022 which focuses on providing extreme heat relief for vulnerable populations. Of the strategies mentioned for bus stops, the City is identifying bus stops currently lacking adequate shade to introduce new bus

68 Climate Action Plan 2021. Phoenix.gov. (2021). https://www.phoenix.gov/oepsite/Documents/2021ClimateActionPlanEnglish.pdf

shelters to improve thermal comfort, but has not yet introduced concrete plans or implemented them. While Boston's intentions are less clear and certain than L.A. under the S.T.A.P. program, Boston does have a mechanism to inform their outdoor heat relief efforts via bus stop interventions. Bus shelter strategies for heat relief are structured around coordination with partners at the state level, and collaboration with the public and community-based organizations to help inform bus shelter placement and shelter design. In addition, Boston plans to create cool streets on major streets that link local destinations to areas of opportunity that also have high temperatures.[69] The cool streets opportunity involves planting street trees, shade structures, vegetation, and installing bus shelters and potentially fans at bus stops.

International City Comparisons

In the international context, Singapore and Dubai are two cities actively planning for urban heat with a sub-focus on bus shelters. These cities have adopted next-generation bus shelter improvements within their overarching aim of heat adaptation. The governance structures of the cities differ from those in the U.S., but the two cities are also utilizing the PPP model for advertising revenue generation at bus stop shelters. Nevertheless, these two cities appear exemplary in adapting to rising extreme heat by structuring their heat-bus shelter plans to their respective microclimatic environments and populations.

In Singapore, temperatures can climb upwards of 27.8°C (80.2°F) in the summer months of May-June.[70] Humidity plays a key factor in extreme heat effects on the population. Projections of higher heat days caused the Singaporean Government to seek out solutions to improve thermal comfort at bus stops that already have existing shade structures to prevent heat stress. The Singaporean Government contracted with Innosparks of ST Engineering to install new smart bus stops with the Airbitat cooling system to address the dual problem of urban heat and pollution and keep track of average waiting time. A trial run to improve thermal comfort in 2018 saw the installation of the Airbitat cooling system in Plaza Singapore Bus Stop

69 Boston Heat Resilience Plan. Boston.gov. (2022). https://www.boston.gov/environment-and-energy/heat-resilience-solutions-boston

70 Meteorological Service Singapore. (n.d.). Climate of Singapore.https:www.weather.gov.sg/climate-climate-of-singapore/.

which became the world's first sustainably cooled bus stop shelter.[71] The system was designed to be energy efficient and environmentally sustainable. The system underwent modifications since its introduction in 2018. The Airbitat served as a valuable amenity to bus stops to cool the surrounding air temperatures down to 75°F, but has only been introduced as a pilot venture.[72] Additionally and more broadly, the Land Transportation Authority of Singapore underwent significant changes in the business model for bus stop shelters that have allowed for improved transit services.[73] The change in the business model represents a positive development in heat adaptation efforts through innovation in collaboration with the private sector by cooling the surrounding environment to improve thermal and perceived comfort at bus stops for transit riders.

The Government of Dubai, in cooperation with the General Secretariat of the Executive Council of the Emirate of Dubai, developed the Dubai Climate Change Adaptation Strategy (DCCAS) to identify heat interventions in key sectors critical to economic well-being.[74] Close collaboration occurs between partners across key sectors that include Dubai's Roads and Transport Authority (RTA) with the implementation of heat adaptation measures carried out in collaboration with the private sector under a PPP framework. While the national plan does not include language on bus stops, the Government of Dubai took direct efforts toward heat adaptation at bus stops. As part of the heat action strategy, the RTA of Dubai plans to expand the existing 2078 bus stops with a recently signed bus shelter contract with a private contractor to build 1,550 new bus stop shelters in high-need areas between 2020-2024 that will have air-conditioning at high transit rider stops.[75] The first four new bus stop shelters were placed in 4 hotspots across Dubai. As implementation of the plan is currently underway, the bus shelter plan is operating under a build-transfer model where advertising revenue at bus stops shelters is shared. The efforts of Dubai

71 Campbell, I. (2021). Beating the heat: A sustainable Cooling Handbook for Cities.https://www.unep.org/resources/report/beating-heat-sustainable-cooling-handbook-cities

72 Smart Cities Connect. (2018). Singapore tests Airbitat Oasis Smart Bus Stop to reduce urban heat and air pollution.https://smartcitiesconnect.org/singapore-tests-airbitat-oasis-smart-bus-stop-to-reduce-urban-heat-and-air-pollution/

73 Government of Singapore, (2019) "Land Transit Master Plan 2040."https://www.lta.gov.sg/content/dam/ltagov/who_we_are/our_work/land_transport_master_plan_2040/pdf/LTA%20LTMP%202040%20eReport.pdf

74 Dubai Air Environment. (n.d.). Climate change. https://dubaiairenvironment.dm.gov.ae/climate_change?lang=en.

75 Roads and Transport Authority (2020). New generation of bus shelters at four Dubai hotspots. https://www.rta.ae/wps/portal/rta/ae/home/news-and-media/all-news/NewsDetails/new-Generation-of-bus-shelters-at-four-dubai-hotspots.

to build an additional 1,550 new bus shelters appear to mirror the intention of the City of L.A. under the S.T.A.P. program to build 3,000 new bus shelters.

2. Bus Stop Field Visits

We conducted bus stop field visits as our second step of primary qualitative analysis. We focused our field visits in Council District 14 because our quantitative analysis identified this district as very high need. We start with the premise that while shade might be provided at certain times of the day from adjacent buildings, bus shelters, trees, and benches are essential for providing heat relief for transit riders.

Figures 5 and 6 show current shelters and their inability to provide shade during peak heat hours (1 pm - 3 pm).

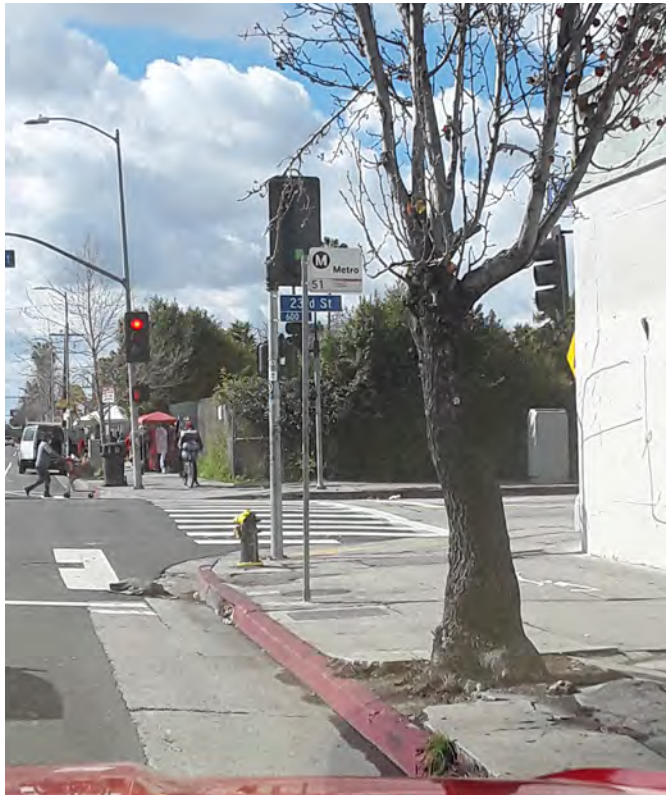
Our field observation began at Bus Line 33 that runs through Council District 14 from Downtown LA on Main Street and East 6th Street intersection with a turn onto 16th Street and then down to Figueroa bordering 18th Street. Of the 11 bus stops observed on bus line 33, only 1 stop (9th and Main) had all 3 components: bench, tree, and shelter structure. Only 5 stops of the observed 30 bus stops along Bus Line 81 had a bench, tree, and shelter structure. Bus Line 51 began in Council District 14 at the San Pedro Street Intersection with Washington cutting into Slauson Ave in Council District 9. Only one bus stop out of the 23 observed in Bus Line 51 had all 3 components. Furthermore, 11 stops along this line did not have a bus shelter.

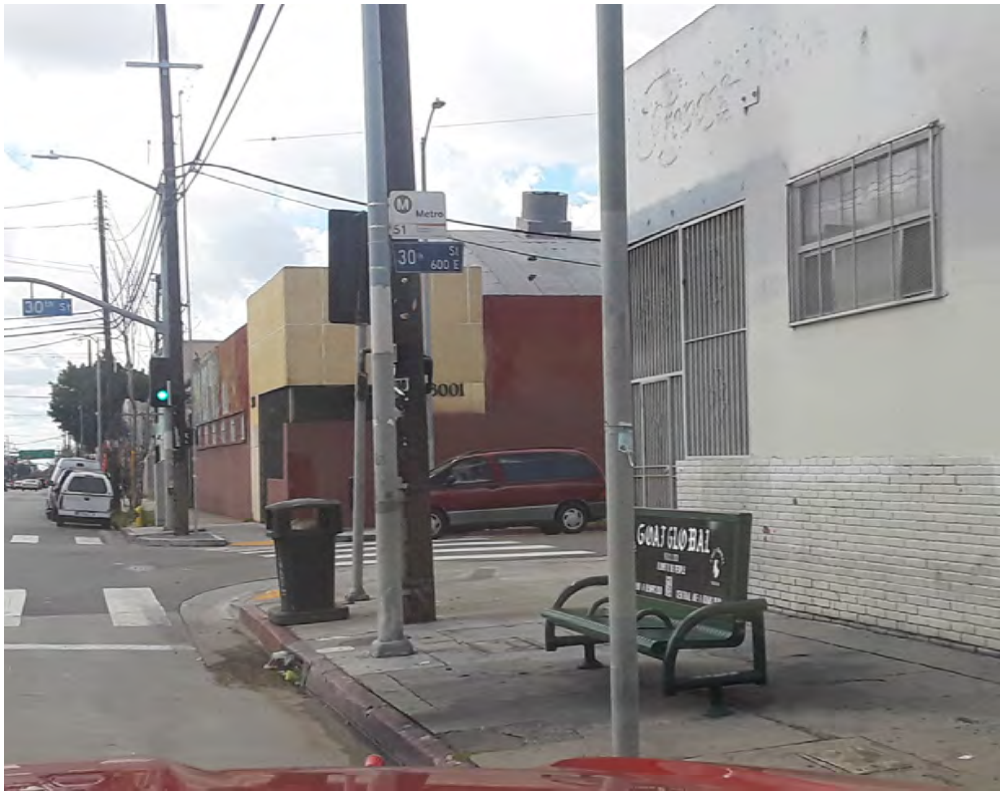
Fig 5 & 6. De Soto and Vanowen Tranzito/Vector Bus Shelter

Source: Images taken by Jose Negrete, May 5th, 2023.

Photos taken between 1:00 pm and 3:00 pm. Images show ineffective shading during afternoon sun. Bus shelter is West-facing and the only shade available is behind the structure in the bushes. This demonstrates the importance of site specific design as opposed to "one-size-fits-all" approaches.

Fig 7 & 8. 23rd Street and San Pedro Street without any bus shelter and 30th and San Pedro Street with a bench- METRO Bus Line 51.





Source: Image taken by Jose Negrete, February 26, 2023, Bus Line 51

We observed an additional five locations along the high-traffic Western/Sunset/ Hollywood corridor that connects multiple bus lines (including high-traffic lines 2 and 207) and also the Hollywood/Western Red (B) Line subway stop. The stops leading up to and around these intersections are high-traffic areas which, when combined with long wait times, do not provide enough street furniture, shade, or amenities for patrons. This corridor is essential for connecting transit riders from the subway to the bus. Two high-traffic connection stops were surveyed. These stops comprise the majority of traffic along the corridor and experience the highest traffic of stops in the area. The lines surveyed were METRO route 2, primarily along Sunset Blvd., and route 217 along Hollywood Blvd. The following figures display street furniture considerations for the two most high-traffic stops.

Fig 9. Hollywood/Western - Route 217/180 Eastbound

Source: Image taken by Abigail Koshollek, Feb 26th, 2023, Route 180 and 217

Fig 10. Sunset/Western - Route 2 Westbound (and LADOT DASH)

Source: Image taken by Abigail Koshollek, Feb 26th, 2023, Route 2 and LA DOT Dash.

Imaage on the right shows the separate unshaded bench for this bus stop.

Neither stop had adequate street furniture and many patrons were seen standing outside of potential shade areas waiting for their bus. The connection stop for Route 2 at Sunset/Western had an additional bench, completely outside the shaded area providing no cover from the elements. At peak hours, riders are not able to find shade or rest and are surrounded by trash and debris from previous days. Recent weather events littered the bench with palm debris, limiting patron access to utilizing structures (see Figure 10).

Finally, along Route 217/180 Eastbound on Hollywood Blvd, examples of removed street furniture were apparent. Figure 11 below shows evidence of a removed bench from an offloading stop specifically for Route 217.

Fig 11. Route 217 offloading stop Vermont/Hollywood

Source: Image taken by Abigail Koshollek, Feb 26th, 2023, Route 217

No indication of the reason for removal was provided at the stop but evidence of interaction with the space was apparent due to blankets and trash left in the area. To the right of the shelter is a bench, completely unshaded. This stop in particular experiences high traffic due to its proximity to the METRO Red (B) Line station at Vermont/Sunset. This Initial assessment shows that there is a lot of work to be done to

bring heat relief to Angelenos utilizing public transit throughout all times of the day.[76]

Finally, the research team visited the site of Tranzito/Vector's pilot of the new street furniture design which was featured in the contract with LA City. While not the original prototype, the shelter surveyed is located at the corner of Chandler Ave and Lankershim Blvd in North Hollywood. Tranzito/Vector highlighted this stop as a commuting transfer stop for Southbound METRO route 224 and LA DOT Commuter Express 549 to Pasadena at the nearest intersection to the North Hollywood METRO Red (B) Line stop, the end of the METRO Red (B) Line. Figures 12 and 13 below show the proposed furniture design, immediately after Route 224 passed and picked up a number of passengers. Notably, the stop itself only has three seats, lacking the ability to accommodate all transfer passengers. The stop did include up-to-the-minute arrival times for route 224.

76 While the research team did not conduct surveys of transit riders to gauge their experiences using public transportation in heat conditions, conditions of bus stops were notably in need of cleaning. Furthermore, the observations allowed the team to note that bus conditions were not sanitary for transit riders. Most of these bus stops were dirty with seats at the sites with benches having trash on them. Several of the bus stops that did include Tranzito/Vector labels were also covered with graffiti and underutilized.

Fig 12 & 13. JCDecaux and Tranzito/Vector Stops in the Field

Images taken by Jose Negrete, February 26, 2023. Figure 6 and 7 are the JC Decaux and Tranzito/Vector bus shelters that our team came across in CD 14 that contrast in cleanliness.

3. Contract Analysis

We next analyzed the text of the City of Los Angeles' new contract document with Tranzito/Vector LLC to examine the extent to which the agreement appears to support equitable heat adaptation. Our analysis provides specific detail on the contract's cost recovery model and proposed implementation criteria in order to determine whether the contract is able to implement recommendations in a timely and equitable manner. We completed this analysis by reviewing the contract document itself, incorporating interview data with StreetsLA, and comparing qualitative research regarding city street furniture financing models in the scholarly and gray literature.

S.T.A.P's broad mandate is to amend and enhance street furniture to provide shelter, shade, safety, and comfort for the City's transit riders.[77] The contract's stated goal is to ensure that at least 75% of the City's bus riders have access to a bus stop shelter by the end of the contract term.[78] Tranzito/Vector estimates the program will cost $236.7 million in capital expenses and an additional $111.5 million in operating expenses over the initial ten-year term. The contract's revenue structure is modeled after the City of London's Street Furniture Cost Recovery model with partner JCDecaux.[79] In both programs, advertisement revenue is projected to completely cover the costs of street furniture, with a goal of little to no impact over the duration of the contract on transit riders or taxpayers.[80] Even in the short term, the City's general fund will not be affected, as the S.T.A.P cost recovery model is designed to completely offset initial capital costs within the first year.[81] The City also aims to rely on the cost recovery model to sustain the S.T.A.P. program over the contract's duration. In the future, there is also a possibility of securing further funding from federal infrastructure grants.

The S.T.A.P financing model, like the City of London's advertisement revenue plan for street furniture, functions under a PPP model of revenue sharing.[82] Ideally, PPPs

77 "CONTRACT between City OF LOS ANGELES and TRANZITO/VECTOR, LLC for SIDEWALK AND TRANSIT AMENITIES PROGRAM (S.T.A.P)."
78 Lance Oishi and Paul Gomez, Conversation on S.T.A.P. Contract with Streets LA. (2023).
79 ibid
80 "CONTRACT between City OF LOS ANGELES and TRANZITO/VECTOR, LLC for SIDEWALK AND TRANSIT AMENITIES PROGRAM (S.T.A.P)."
81 Lance Oishi and Paul Gomez, Conversation on S.T.A.P. Contract with Streets LA. (2023).
82 Iveson, Kurt. 2012. "Branded Cities: Outdoor Advertising, Urban Governance, and the Outdoor Media Landscape." Antipode 44(1): 151–74.

serve to function in ways that both avoid traditional bureaucratic hurdles of city governments while capitalizing on the flexibility and financial resources of the private sector. PPPs are common in street furniture contracts across the globe and have resulted in a growing number of "branded cities," where visual advertisements are homogenized globally.[83] As a result, some global cities, including London and Los Angeles, rebranded themselves and collaborated as "innovation cities" implementing novel ideas in the transportation sector, including the aforementioned cost recovery model.[84]

This framing reflects that hurdles to investment in public infrastructure within the City of Los Angeles are no different than in its urban global counterparts.[85] Funding, capital, and resources for public entities are in short supply in LA and in cities across the globe, oftentimes necessitating the move to the PPP in the absence of another revenue stream. Still, a PPP does not equate to a cost-less program for the City itself. In actuality, cities with advertising-driven PPP models often spend large amounts of money in order to "clean up" graffiti on advertisements and tend to prioritize maintenance on bus shelters where advertisements are seen the most.[86]

This branded and contracted approach to street furniture contracts, especially the new revenue share secured under S.T.A.P., from one perspective appears as a relative success story for the City. However, reliance on PPP financing models, in a context where the city also makes universal service commitments to self-finance other essential infrastructure and services, ultimately conveys a lack of commitment from city government to those who utilize bus infrastructure and street furniture because the city is not investing its own capital expenditures into the infrastructure.[87] Such an arrangement may also limit the ability for the city to innovate based on community needs. A city under a PPP model prioritizes certain elements of street furniture that advance revenue from advertising rather than strategies that might be best for riders' health and safety. These tradeoffs are illustrated in the following figure of S.T.A.P. program elements found within the City's contract with Tranzito/Vector. Table 3 below outlays S.T.A.P.'s desired Program Elements categorized as "essential," "secondary," and

83 ibid
84 Matters, "London and Los Angeles Announce Collaboration on Transport Innovation."
85 ibid
86 Iveson, Kurt. 2012. "Branded Cities: Outdoor Advertising, Urban Governance, and the Outdoor Media Landscape." Antipode 44(1): 151–74.
87 ibid

"additional" elements.

In this framing, content management systems, digital displays, and icon panels are of equal priority to the City as shade structures and shelters. While the contract with Tranzito/Vector specifies element minimums that the program in general must meet, there is little specificity regarding where shelters, shade structures, and other elements should be placed. The contract broadly calls for "equity" and includes mention of equity metrics in providing city residents these services, but does not describe specifically how equity will be reached. While the contract does specify an initial scope for year 1 shelter implementation, it is very vague regarding equity outcomes.

Table 2: S.T.A.P. Program Elements

Essential	Secondary	Additional Elements
Transit Shelters (goal of 3,000 units)	Kiosks	Solar Options/Grid Storage at Transit Shelters
Shade Structures (goal of 450 units)	eCommerce Lockers	Hydration Stations
Litter Receptacles (goal of 1 unit per Transit Shelter)	Scooter Docks	Hand Sanitation Stations
Digital Displays / Real Time Info (Real Time Info displays at every Transit Shelter)	5G	Sensors (ex. heat , pedestrian and vehicular counts, air quality)
Emergency Call Features	Public Wifi	Integration of Fare Payment (eg. TAP stations)
Content Management System	Phone Charging	Cooling Devices (eg. misters)
Icon Panel (est. max. Qty 100 at Transit Shelters)	Urban Panels	Requested alternative furniture elements paid for by third parties (eg. METRO BRT “stations” or equal) for special programs

QUANTITATIVE ANALYSIS AND FINDINGS

Case Study Evaluating the Equity of First-Year S.T.A.P. Allocations

The analysis of the S.T.A.P. contract brings attention to the limitations of a PPP model when it comes to implementing public infrastructure projects that adequately address the unique needs of an area. In our evaluation of the initial implementation of the S.T.A.P. program, we examined StreetsLA's multi-tiered prioritization system for bus stops, which aimed to identify high-priority areas requiring immediate attention based on various criteria. However, the lack of information from StreetsLA regarding the use of this system to select bus stations for shelter installation or determine shelter prioritization raises concerns about the effectiveness of the program in addressing heat equity for transit riders.

To analyze the program's performance, we conducted an assessment of existing transit shelter distribution patterns in comparison to the StreetsLA prioritization ranking and the first-year allocations of shelters for the S.T.A.P. This evaluation aimed to understand whether the program effectively utilized its new multi-tiered system to address heat equity for transit riders.

Our analysis began by selecting specific council districts in Los Angeles based on projected mid-century maximum temperatures obtained from the California Heat Assessment Tool (CHAT) and the current availability of bus shelters. This enabled us to identify districts with varying levels of heat vulnerability and disparities in shelter infrastructure. We then narrowed our focus to three districts, representing high, moderate, and low differences in projected heat and shelter availability. By considering these factors, we sought to gain a comprehensive understanding of the diverse challenges and needs within the city.

In our analysis, we employed various data points to compare and contrast the three

selected council districts in terms of their heat vulnerability and bus shelter needs and the S.T.A.P. was able to address those concerns through the implementation of their new prioritization system. Below is an overview of the calculations we utilized:

1. Mid-century maximum heat projections obtained from the California Heat Assessment Tool (CHAT)
2. Count of S.T.A.P. stops classified as very high and low priority
3. Wait times at METRO serviced bus stops
4. Overall bus stop activity (boarding and off-boarding)
5. Commute trips by bus, median household income, and council district population

To access the mid-century maximum heat projection data, we utilized the California Heat Assessment Tool (CHAT). This tool provided us with June, July, and August heat projections between the years 2021 and 2040, based on the pollution model RCP 8.5. The S.T.A.P. priority ranking data was obtained directly from StreetsLA, while our first-year S.T.A.P. allocation data was sourced from the February 2023 update, which we downloaded from StreetsLA's ArcGIS online hub. To contextualize the allocation of proposed shelters in the three selected council districts, we drew population and median income estimates from the 2019 American Community Survey 5-year estimates at the tract level.

Furthermore, we calculated the total "person-minutes" in each of these districts, as suggested by Law and Taylor, by multiplying stop-level ridership and headways.[88] "Person-minutes" is an ideal metric because it provides valuable insights into heat exposure, as it captures the collective amount of time riders spend waiting for transit, often exposing them to the elements. Headways are defined as the amount of time between transit vehicle arrivals at a stop.[89] We utilized ridership data from October 2019 downloaded from StreetsLA's ArcGIS online hub and calculated headways using LA METRO's static General Transit Feed Specification (GTFS) data from the same period. GTFS data is the universal data standard for transportation agencies to provide route and schedule information to trip routing services such as Google Maps. It is important to note that the use of static GTFS data only reports scheduled headways

88 Law, Philip, and Brian D. Taylor. "Shelter from the Storm: Optimizing Distribution of Bus Stop Shelters in Los Angeles." Transportation Research Record 1753, no. 1 (January 1, 2001): 79–85. https://doi.org/10.3141/1753-10.

89 ibid

and not observed headways. Additionally, due to a slight misalignment between the bus stops in the ridership and GTFS datasets, we were unable to calculate person minutes for each METRO bus stop in the council districts. Our data includes 255 bus stops in Council District 3, 239 bus stops in Council District 5, and 534 bus stops in Council District 14.[90] We were able to calculate the total and average person minutes for each council district by summing the average headway multiplied by the total weekday onboardings for each METRO bus stop in our sample. This represents the total/average amount of time bus riders wait at the bus stop in each council district. For reference, we also include the average weekday headway and average weekday ridership for each council district.[91]

Lastly, we calculated the mode share of commute trips by bus and the total bus stop activity of the METRO stops in each council district. Mode share reflects the proportion of people in a district who rely on bus transit for their daily mobility. However, it is important to note that this metric does not consider the fact that people often live far from their workplaces. Bus stop activity was calculated by multiplying the total onboardings and alightings at each bus stop, representing the total activity occurring at the stops. Bus stop activity data was sourced from StreetsLA's ArcGIS online hub for October 2019, while mode share data was sourced from the 2019 ACS five-year estimate tables.

Our analysis compares these equity indicators to the proposed first-year S.T.A.P. installations to evaluate the extent to which the S.T.A.P. program provides equitable heat adaptation to Los Angeles bus riders. The definition of equity used in this study aligns with the Los Angeles Climate Emergency Mobilization Office (CEMO), which defines equity as the attainment of full and equal access to opportunities for all people, enabling them to reach their full potential. This definition differentiates equity from equality by recognizing that fairness requires providing different things to individuals based on their unique needs.[92]

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90 Coordinates, naming conventions and bus stop numbers did not match. The METRO ridership data also had more bus stops in their dataset than the GTFS data.

91 Note that these numbers (average council district headway and average council district ridership) were not the numbers used to calculate the person-minutes. To calculate person minutes, we multiplied the average headway of each stop by the total weekday onboardings for each stop. Using the average council district headway and average council district ridership will generate different results. Our approach considers the stop level person-minutes which provides a more cumulative understanding.

92 "About." Climate Emergency Mobilization Office, 19 June 2022, https://www.climate4la.org/about/.

1. Council District Selection

To systematically select the three council districts for our case study, we employed a methodology based on two key variables: mid-century maximum temperature projections and the percentage of METRO bus stops with shelters. Our aim was to choose districts that would be representative of Los Angeles' diversity in terms of heat vulnerability, existing shelter infrastructure, and geographic location.

We first considered mid-century maximum temperature projections obtained from the California Heat Assessment Tool (CHAT). These projections provided us with valuable insights into the expected heat levels in different areas of Los Angeles. We wanted to include districts with a range of heat projections to capture the varying levels of heat vulnerability within the city.

Secondly, we examined the percentage of METRO bus stops within each council district that already had shelters. This information allowed us to assess the existing shelter infrastructure in each district. By selecting districts with different percentages of bus stops with shelters, we could explore the disparities in shelter availability and understand the potential gaps in addressing heat equity for transit riders.

In addition to these two variables, we took into account the geographic location of the council districts. We aimed to include districts from different parts of the city to ensure a comprehensive representation of Los Angeles' diverse needs and challenges.

By considering the mid-century maximum temperature projections, the percentage of bus stops with shelters, and the geographic location, we were able to systematically select three council districts that would provide a comprehensive understanding of the heat vulnerability, existing shelter infrastructure, and diverse characteristics within Los Angeles

Heat Projections

StreetsLA utilizes heat projections based on the California Heat Assessment Tool (CHAT) as part of their ranking methodology. The CHAT models heat projections

during a Heat Health Event (HHE). HHEs are defined as any heat event that generates public health impacts, regardless of the absolute temperature. CHAT projects daily temperature and relative humidity ranges using historical meteorological data (1984-2013) and emergency department visitation data (2005-2013). It uses a subset of climate and pollution data to determine the daily minimum and maximum relative humidity in addition to daily minimum and maximum temperature. We also use CHAT in our selection procedure to standardize our methodologies. We select three Council Districts with low, moderate, and high projected maximum average temperatures between the years 2021-2040 during the months of June, July, and August based on the RCP 8.5 pollution model.

Bus Shelter Inventory

A 2023 study conducted by the UCLA Lewis Center for Regional Policy Studies analyzed the spatial distribution of Los Angeles County's METRO bus shelters. Of the 10,527 bus stops examined in their study, only 26% were equipped with a shelter. We utilize the transit shelter inventory database they created which was provided to us by Madeline Brozen, deputy director of the UCLA Lewis Center for Regional Policy Studies, to set the groundwork for our analysis. We restricted the data to only include METRO bus stops within the City Council Districts. From this we found that only 23% out of the 6,331 METRO bus stops were equipped with a bus shelter. We acknowledge that there are other transit operators in the region who have their own separate bus stops, however, we did not employ bus shelter data for these stops. We consider the overall percentage of METRO bus stops with shelters in each council district and select three council districts that represent a range of existing shelter allocations.

Final Council District Selection

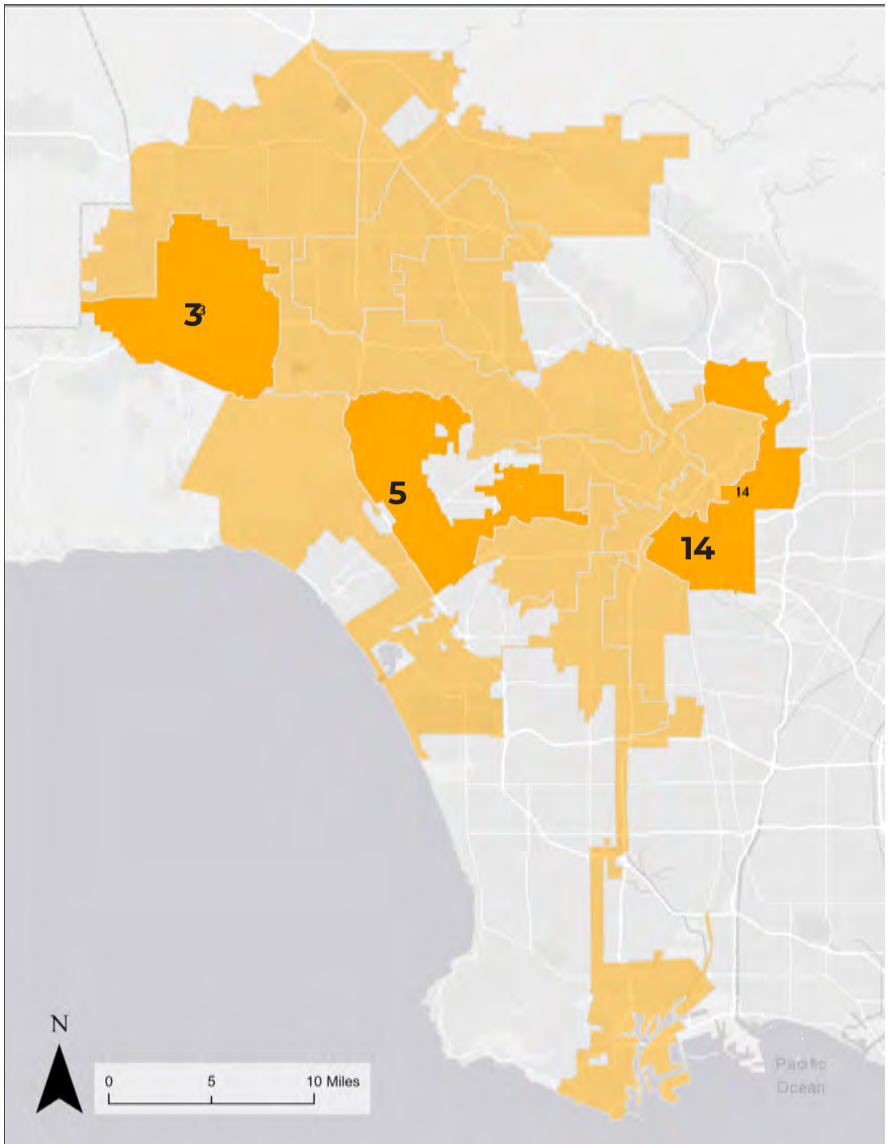
Based on our methodology, we have selected Council Districts 3, 5, and 14 for our case study. These districts were chosen to represent a range of heat vulnerability, existing shelter infrastructure, and geographic locations within Los Angeles (refer to Table 3 and Figure 14).

Council District 3: This district represents an area with high heat vulnerability (106 - 110°F) and a slightly higer than average percentage of METRO bus stops with shelters (24.9%). It allows us to analyze the effectiveness of the S.T.A.P. program in addressing heat equity in districts that already have existing shelter infrastructure but face high heat vulnerability

Council District 5: This district represents an area with relatively low heat vulnerability (94 - 98°F) and the highest percentage of METRO bus stops with shelters (32.2%). It serves as a baseline comparison and allows us to examine the effectiveness of the S.T.A.P. program in addressing heat equity in a district with substantial shelter infrastructure.

Council District 14: This district represents an area with moderate heat vulnerability (98 - 102°F) and a below average percentage of METRO bus stops with shelters (18.8%). It highlights the challenges faced by transit riders in areas with limited shelter infrastructure and helps us assess the impact of the S.T.A.P. program in addressing heat equity in such districts.

Fig 14. Case Study Council Districts Map



Map of LA City Council Districts highlighting 3, 5, and 14 which we use for our case study analysis

Table 3. Heat Projections and Percent of Shelters by Council District

Council District	CHAT Heat Projection(°F)	Count of METRO Bus Stops	Count of Current METRO Bus Stops with Shelters	Current Percent of METRO Bus Stops with Shelters
1	94-98	438	112	25.6%
2	102-106	428	80	18.7%
3*	106-110	438	109	24.9%
4	102-106	378	100	26.5%
5*	94-98	317	102	32.2%
6	102-106	475	106	22.3%
7	102-106	386	96	24.9%
8	90-94	461	94	20.4%
9	90-94	495	96	19.4%
10	90-94	468	114	24.4%
11	90-94	254	52	20.5%
12	102-106	447	81	18.1%
13	90-94	426	115	27.0%
14*	98-102	661	124	18.8%
15	90-94	259	44	17.0%

* indicates selected Council Districts.

2. Case Study Findings: S.T.A.P. Shelter Planning, Heat, and Social Vulnerability

We examine here the relationships between equity considerations and first-year S.T.A.P. shelter allocation. Our explanatory variables are:

1. CHAT mid-century maximum heat projections
2. Count of S.T.A.P. very high and low priority stops
3. How much time riders wait at METRO bus stops
4. Overall bus stop activity frequency (the sum of boardings and off-boardings of each METRO stop in the district)
5. Commute trips by bus
6. Median household income
7. Council District population

Table 4 presents a comprehensive overview of all the variables considered, categorized into three topics: Heat and Shelters, Socioeconomic Demographics and Transit, and S.T.A.P. Rankings. The table also compares these variables to the total number of proposed first-year S.T.A.P. installations in each council district.

Table 5. Case Study Analysis Results

	CD 3	CD 5	CD 14
Heat and Shelters			
Projected Maximum Temperature (°F) between 2021-2040	106-110	94-98	98-102
Count of Total METRO Bus Stops	438	317	661
Current Percent of Bus Stops with Shelters	24.90%	32.20%	18.80%
Socioeconomic Demographics and Transit			
Total Population	200,396	186,370	214,584
Average Median Income	$88,145	$104,955	$60,667
Percent of Commute trips by Bus	3.70%	3.60%	8.90%
Sum of METRO Bus Stop Activity (boardings + alightings)	28,124	39,337	172,386
Average Weekday Bus Ridership (riders per hour)	44	60	164
Average Weekday Headway (minutes between bus arrivals)	23	11	12
Total Person Minutes (riders * headway)	157,966	96,257	460,757
Average Person Minutes	620	402	862
S.T.A.P. Rankings			
Very High Priority Stops	24	5	177
High Priority Stops	91	41	192
Moderate Priority Stops	151	189	337
Low Priority Stops	189	279	366
First Year S.T.A.P. Shelters	**30**	**84**	**55**

Heat and Shelters

Through June – August between 2021 and 2040, Council District 3 is projected to have the highest mid-century maximum temperatures, ranging from 106°F to 110°F. In contrast, Council District 5 has the lowest projected temperatures, though it will still experience substantial extreme heat. However, Council District 5 is the most equipped district to handle the projected temperatures as it has the highest percentage of bus shelters relative to the number of bus stops within its boundaries. Council District 14 is considered the least equipped district, with only approximately 18% of its stops having bus shelters, despite projected maximum temperatures ranging from 98°F to 102°F. The allocation of first-year S.T.A.P. shelters seems to perpetuate existing inequities, as Council District 5 will receive 85 shelters despite already having a high relative percentage of bus shelters. The data does not suggest that heat is a crucial consideration in bus shelter allocation from the S.T.A.P. program. The proceeding sections attempt to discern potential explanations for what other considerations may currently be prioritized.

Socioeconomic Demographics and Transit

To gain further insights into the potential explanations for the first-year bus shelter allocations, we examine socioeconomic variables for each council district. Transit users in these districts typically include low-income people of color residing in low-income neighborhoods without access to private vehicles (as described in the Project Aim section of this report). Since the definition of low-income can vary based on region and household size, we utilize the relative average median household income between these three districts. Council District 5 is classified as high-income, Council District 3 as moderate-income, and Council District 14 as low-income. Focusing on income, we observe that Council District 5 has a significantly higher average median income compared to the other two districts, with a difference of over $40,000 per year more than Council District 14. Additionally, Council District 5 has the smallest population among the three districts.

In line with broader trends, Council District 14 has the highest percentage of commute trips by bus, more than double that of Council District 3 and Council District 5. Council District 14 also experiences disproportionately high bus stop activity, with a total

of 172,386 weekday boardings and off-boardings. This, along with the mode share, indicates that a higher proportion of Council District 14 residents rely on bus transit for their mobility compared to the other two districts. This pattern aligns with extensive literature linking transit dependency to low and median-income groups.[93]

In addition to having the largest bus stop activity, Council District 14 has the highest average and total person minutes (1,968 and 460,757 minutes respectively). More bus riders are spending time waiting for the bus in Council District 14 than in Council District 3 or Council District 5. While Council District 14 and Council District 5 have similar headways, there are substantially more people waiting for the bus in Council District 14 than in Council District 5, resulting in a higher total amount of human exposure to heat. Riders in Council District 14, a low-income council district, are utilizing transit more in Council District 5 and Council District 3 both in terms of total bus stop activity and total ridership. Despite the ridership balance, Council District 14 will receive ~30 fewer new shelters in the first year of the S.T.A.P program than Council District 5.

S.T.A.P. Rankings

We analyzed the current list of proposed first-year S.T.A.P. shelters provided by StreetsLA in these districts and summarized the priority ranking of the bus stops. According to StreetsLA, a very high-priority stop was defined as one with high transit ridership, high projected heat exposure, located in a METRO Equity Focused Community (EFC), and in close proximity to trip generators, key destinations, and service facilities. It is important to note that variations in these priority indicators may exist, meaning that some bus stops could have a high score in the heat category but a low total score if they performed poorly in other categories.

CD 5 had the fewest very high-priority stops (5) and high-priority stops (41), while Council District 14 had the most very high-priority stops (177) and high-priority stops (192). Unfortunately, the individual ranking of each proposed first-year shelter in the three focus districts was unknown. However, it was evident that the first-year shelter allocations did not align with the ranking of stops: Council District 5, which had the

93 Lanza, Kevin, and Casey P. Durand. 2021. "Heat-Moderating Effects of Bus Stop Shelters and Tree Shade on Public Transport Ridership." International Journal of Environmental Research and Public Health 18(2): 463.

fewest high-priority stops, received more shelters than Council District 14, which had the most.

Case Study Analysis Summary

Our analysis revealed that Council District 3 was the hottest of the council districts, which meant its transit riders may have endured potentially dangerous conditions while waiting for the bus. However, Council District 14 had the lowest income among the three council districts and was also projected to have considerably high temperatures. Council District 14 experienced a disproportionately high total bus stop activity and mode share, indicating that residents were more dependent on bus transit for their mobility than in the other districts. Person minutes in Council District 14 also indicated that more people had to wait longer at bus stops in an area that was poised to experience maximum temperatures ranging from 98°F to 102°F between the years 2021 and 2040.

Out of all three districts, Council District 5 was the most equipped to have its residents adapt to intensifying extreme heat events. The district had 32% of bus stops within its boundaries equipped with shelters. It was also the wealthiest district among our case studies, with the lowest projected maximum temperatures, the lowest percent of commute trips by bus, and the shortest wait times. In the first year of the S.T.A.P program, Council District 5 increased its current heat adaptation capacity by having 85 new shelters installed. We found a disconnect between planned first-year S.T.A.P. allocations and the specific needs of residents in our case study council districts.

If bus shelter allocations reflected a prioritization of heat and equity in StreetsLA's ranking system, we would expect to see variables like income and ridership related to first-year shelter installation. However, the current plan sees Council District 14 receiving fewer shelters than high-income, low-ridership areas despite its 177 very high-priority stops.

The current first-year allocation of bus shelters under the S.T.A.P. did not match the prioritization or working definition of equity set by CEMO, where each person could acquire the same thing to achieve fairness. To distribute bus shelters equitably, looking forward StreetsLA needed to prioritize installation in Council District 14, Council District 3, and other underserved areas rather than looking first to wealthy, cooler

districts like Council District 5. Under the current plan, we found that the S.T.A.P. did not adequately or equitably provide immediate heat relief for Los Angeles' transit riders. Moreover, the motivations and criteria driving the current shelter allocation scheme were neither public nor easily discerned; they did not appear to relate to either the StreetsLA ranking system, transit ridership or dependence, current shelter distributions, or heat projections.

DISCUSSION

The findings of our study revealed significant disparities in the equitable placement of bus shelters in the City of Los Angeles, particularly in relation to heat exposure and vulnerability. These disparities have larger implications for social equity, public health, and climate resilience. Our bus stop field visits highlighted the lack of basic amenities such as bus shelters, benches, and trees at many bus stops in Council District 14, putting transit riders, especially those from low-income communities, at greater risk of heat-related illnesses and discomfort. This baseline status underscores the urgent need for immediate action to address the heat-related challenges faced by bus riders and ensure equitable access to essential infrastructure.

Our cross-city comparison findings also indicate that cities around the world structured their bus stop shelter installations under the PPP contract model as part of their heat adaptation efforts. However, the overdependence on advertising revenue under this model made it difficult to prioritize equity in bus stop shelter allocations. The first-year allocations of bus shelters in the S.T.A.P program seemed to be driven by revenue potential at high-performing bus stops for advertising rather than heat adaptation efforts. Although the contract aims to provide bus stop shelters to protect 75% of transit riders in Los Angeles, the logic used to select bus shelter sites did not appear to align with the published StreetsLA ranking system.

Municipalities both domestic and abroad are beginning to produce heat and climate action plans for extreme heat adaptation. Our findings indicate that only a few jurisdictions currently include bus shelter enhancements as part of their heat adaptation strategy. Microclimatic conditions vary across these cities and necessitate different criteria for bus stop shelters, but municipal approaches are similar globally.

Measures for extreme heat adaptation depend heavily on the PPP model of cost recovery for bus shelter replacement. The S.T.A.P contract is structured as a self-sustaining program dependent on private contractors to generate advertising revenue at bus stops for developing essential public infrastructure. The continued reliance on the PPP model in the S.T.A.P program is worrying based on the prior 20-year contract with JCDecaux failing to meet its target of new bus shelters and revenue for the City under the Coordinated Street Furniture Program. The CEMO should coordinate with StreetsLA to advocate for priority bus stop shelter placement selection as part of its Extreme Heat Action Plan.

Our analysis of 3 council districts also suggests that there are inconsistencies between StreetsLA's priority ranking of bus stops and the first-year allocation of new shelters. Council District 5, with the highest median income, lowest projected temperatures, and shortest bus wait times, among the three districts, is receiving ~30 more new shelters in the first year than either Council District 3 or Council District 14. Although Council District 14 and Council District 3 are receiving new bus shelters, the relative proportions of shelters to bus stops still remain substantially higher in Council District 5. The StreetsLA ranking system was designed to reflect the local need for shelters, but early S.T.A.P. allocations do not ameliorate inequities.

The purpose of a priority ranking system is to assist in decision-making by removing subjectivity and undue discretion from the process and ensuring the inclusion of social objectives beyond revenue return. However, as the ranking system does not align with the implementation plan, it is unclear what factors go into the actual decision to install shelters at bus stops. Tranzito/Vector and StreetsLA have made the selection process opaque; it is not clear whether the allocation structure will eventually address citywide inequities or projected heat exposure.

The findings of the quantitative analysis have important implications for addressing the intersection of heat vulnerability and equity in the context of public transportation. The disproportionate allocation of bus shelters in Los Angeles raises questions about the fairness and effectiveness of the current S.T.A.P. planning strategy. By favoring wealthier districts with lower temperatures and lower transit dependence, the existing shelter allocation scheme perpetuates inequities and neglects the needs of low-income communities facing higher heat exposures. Additionally, the findings emphasize the need to prioritize underserved areas with high heat exposure and

transit dependence when allocating resources such as bus shelters. Low-income districts like Council District 14, characterized by higher bus stop activity, ridership, and longer wait times, require immediate attention to mitigate the potential health risks associated with prolonged exposure to extreme heat while waiting for public transportation. By focusing on equitable shelter allocation, policymakers and municipalities can demonstrate their commitment to reducing disparities and improving the resilience of vulnerable communities in the face of climate change.

Overall we conclude that the S.T.A.P. is not adequately or equitably prioritizing bus stop shelter placements in the most vulnerable council districts thus far. Addressing the larger implications of these findings requires a multi-faceted approach. It is still early in the contract life cycle, potentially enabling changes to occur that may refocus equity and heat protections in bus shelter placement. Additionally, it necessitates targeted investments in underserved areas, such as Council District 14, to ensure that the allocation of shelters aligns with the specific needs and challenges faced by marginalized communities.

However, the PPP itself, its execution in the contract, and the first year of prioritized shelters give us pause as to exactly how the S.T.A.P program could ensure that bus shelters are seen as public infrastructure for heat adaptation in the City of LA. The City has an opportunity to leverage the new contract in combination with other City goals to prioritize heat equity in shelter planning. From an initial assessment, it is evident that there is a lot of work to be done to bring heat relief to Angelenos utilizing public transit throughout at all times of the day.[94]

CONCLUSION

While StreetsLA's ranking criteria are promising and consider several essential equity-oriented variables, the actual decision-making process regarding shelter installations first is vague. It is unclear how StreetsLA selects which bus stops from their priority

94 While the research team did not conduct surveys of transit riders to gauge their experiences using public transportation in heat conditions, conditions of bus stops were notably in need of cleaning. Furthermore, the observations allowed the team to note that bus conditions were not sanitary for transit riders. Most of these bus stops were dirty with seats at the sites with benches having trash on them. Several of the bus stops that did include Tranzito/Vector labels were also vandalized with graffiti and underutilized.

list require immediate attention over others. The outcomes of the first year of stop revitalizations and shelter installations reinforce both heat and street furniture inequities. This discrepancy indicates that other priorities, particularly revenue potential, may be more important than either heat exposure or ridership through the early phases of the S.T.A.P. program.

The implementation of the S.T.A.P. and the adoption of a PPP model in Los Angeles represent a notable fiscal advancement compared to previous contractor arrangements. However, there is limited evidence to support the notion that this PPP model can adequately address the diverse needs of individual council districts and their transit riders. Studies examining "branded cities" operating on a PPP revenue recovery model indicate that these models prioritize a standardized transit experience, both globally and locally, rather than catering to the specific requirements of individual riders. The lack of flexibility may lead to an inequitable distribution of heat mitigation and shelter initiatives, with a greater emphasis placed on advertising and revenue generation rather than addressing the unique needs of transit users.

Our research suggests that the S.T.A.P program, in its current version, does not adequately or equitably provide heat relief for Los Angeles bus riders. This is not to say that the program cannot or will not be amended. We believe that S.T.A.P. and more broadly the City of Los Angeles has the potential and the obligation to be a leader in innovative extreme heat adaptation. Our recommendations for improving equity within S.T.A.P. are thus as follows:

RECOMMENDATIONS

1. Treat Bus Shelters as Public Infrastructure

Bus shelters are necessary public infrastructure for equitable and dignified mobility and should be treated as such. Relying on PPP models inevitably precludes cities from providing the greatest good for the most in need. We recognize that the PPP model is the common method used by other cities, but this speaks to the larger structural issue of inequitable bus shelter allocation and shade availability. Just as roads and sidewalks are considered necessary public infrastructure as opposed to luxury goods

only available to specific areas and specific people, bus shelters also deserve this designation and investment strategy. In order for infrastructure to be viewed and valued as a public good, cities must invest their own capital without reliance on a cost recovery mechanism into these projects. Simply put, Los Angeles must transition to utilizing its own general fund for street furniture if it hopes to truly center heat and shade in its shelter distribution. Cost recovery models such as PPPs likely do not have the capacity to prioritize both revenue and equity in street furniture. Using this framework can change the City's approach to bus shelter allocations to one that centers equity instead of cost-recovery potential.

2. Coordinate S.T.A.P. with other Heat Adaptation Efforts in L.A.

Effective collaboration among various stakeholders is crucial in addressing the impact of extreme heat through the implementation of transit shelters. To ensure the development of heat-resilient infrastructure, city officials, transit agencies, urban planners, and community organizations need to work together in a coordinated manner. Engaging with relevant organizations such as Climate Resolve and Pacoima Beautiful, which have already been actively involved in community-led heat planning, can provide valuable insights and expertise specific to their respective areas. By collaborating with these organizations, the city can benefit from their research, planning, and implementation efforts, and ensure that heat adaptation strategies are tailored to local needs.

Additionally, it is essential for the city to streamline heat planning initiatives within individual council districts. By maintaining strong relationships with communities most affected by extreme heat, the city can better understand their unique challenges and develop targeted solutions. Prioritizing the CEMO is crucial for the long-term sustainability of heat planning in Los Angeles. City officials should actively support and allocate resources to CEMO to ensure that heat mitigation and shelter planning remain a priority for the city, even as new challenges arise in the future.

3. Democratize Bus Shelter Placements

There is a need to expand efforts in collaboration with Community-Based Organizations (CBOs), as highlighted in our UCLA Masters of Public Policy's work

with CEMO, to identify priority bus stop shelter placements and criteria. CBOs play a crucial role in representing the lived experiences of transit riders and can provide valuable insights into the specific needs and challenges faced by communities. The inclusion of CBOs will support the efforts of StreetsLA by identifying priority bus stops in need of heat adaptation amenities to protect transit riders that are exposed to heat. Including CBOs and transit riders in bus shelter placement creates direct stakeholdership between StreetsLA, CBOs, and members of the public to have a say in how their communities become heat resilient to provide thermal comfort. Currently, the selection of which stops get new bus stop shelters is vague. Participatory planning allows democratization of planning to involve members most vulnerable to extreme heat to be engaged in priority bus shelter selection for improving thermal comfort.

4. Consider Analyzing Different Heat-Related Measures, including Local Climate Zones, for Bus Shelter Allocation

Planning for climate change, specifically heat, is a challenging task because scales of exposure and intervention vary by setting. The LCZ classification system as defined by Stewart and Oke consists of 17 zones based mainly on built types and surface cover. The system is originally designed to provide a framework for urban heat island studies, allowing the standardized exchange of urban temperature observations. There are multiple benefits to using this system which allows systematic comparability of global intra- and inter-urban heat island studies and provides a platform for generalization of the urban environment. Multiple climate assessments have been done using the LCZ system, especially for heat. For a program like the S.T.A.P. that requires a micro-level intervention, an LCZ-level analysis of bus stops could be beneficial to understand the changes in heat across council districts.

5. Introduce Specific Field Impact Metrics and Reporting Systems to Measure Success

The use of transparent metrics is crucial for evaluating and assessing the effectiveness of programs like S.T.A.P. By implementing procedural measurements, similar to the approach taken in Boston, it becomes possible to determine whether the program is successfully achieving its objectives. In the case of heat relief, installing

sensors at bus shelters to measure micro-scale temperatures can provide valuable insights into the effectiveness of the program and inform future decision-making processes. Collecting data on micro-scale temperatures around the new shelters allows for a comprehensive understanding of their impact on local heat conditions.

This data should be used to assess the effectiveness of different shelter designs and placement strategies in maximizing shade availability and providing thermal comfort for transit riders. By analyzing the micro-scale temperature measurements, municipalities can make informed decisions about the design and allocation of shelters to ensure they effectively mitigate heat and create comfortable environments. Other municipalities can utilize this information to inform their own transit heat adaptation strategies. By establishing a framework for measuring and evaluating the impacts of bus shelters on local heat conditions for residents, cities can exchange best practices and collaborate on effective heat resilience strategies, leading to more widespread and impactful implementation of transit heat adaptation measures.

DIRECTIONS FOR FUTURE RESEARCH

Future efforts might also investigate more thoroughly the strategies that StreetsLA and Tranzito/Vector are using to prioritize bus shelter installation to better understand both their internal priorities and how the long-term contract might evolve. We cannot find evidence that the current city contract is resulting in the allocation of bus shelters in an equitable manner to protect transit riders from heat in the most vulnerable council districts. An additional study should focus on defining equity in the realm of public transit planning during periods of extreme heat and could ask whether transit agencies are necessarily bound to choose between reducing heat inequities or achieving a return on investments. Future research on extreme heat adaptation strategies through bus shelters should focus on developing and delivering transparent, equitable allocation methodologies and their implementation in future years of this and other city shelter programs globally.

ACKNOWLEDGMENTS

Our project was shaped by interviews with key stakeholders, individuals and organizational representatives including:

- Catherine Baltazar, Policy Analyst and Organizer, Climate Resolve
- Chase Englehardt, UCLA ITS Graduate Student Researcher, Climate Resolve
- Client partners Rebekah Guerra Day and Marta Segura of the City of Los Angeles Climate Emergency Mobilization Office.
- Dr. Adonia Lugo, UCLA ITS Equity Manager
- Dr. Gregory Pierce, UCLA Urban Planning Professor
- Dr. Ruth Engel, UCLA Luskin Center for Innovation
- Eli Lipmen, Executive Director, MoveLA
- L.A METRO
- LADOT
- Madeline Brozen of the UCLA Lewis Center for Regional Policy Studies
- StreetsLA
- Tamika Butler, Doctoral student, Urban Planning, UCLA Luskin School of Public Affairs
- Visiting Professor C.J Gabbe of Santa Clara University

Our team is thankful for their support in providing valuable information and data for our project.

FROM COOLING TO RESILIENCY:

How can City of Los Angeles Cooling Centers be better Utilized, Grow in Connectivity, and Function as Community Resilience Centers?

Diana Alcocer
Michelle Gallarza
Amanda Gormsen
Corinne Odom

chapter 3

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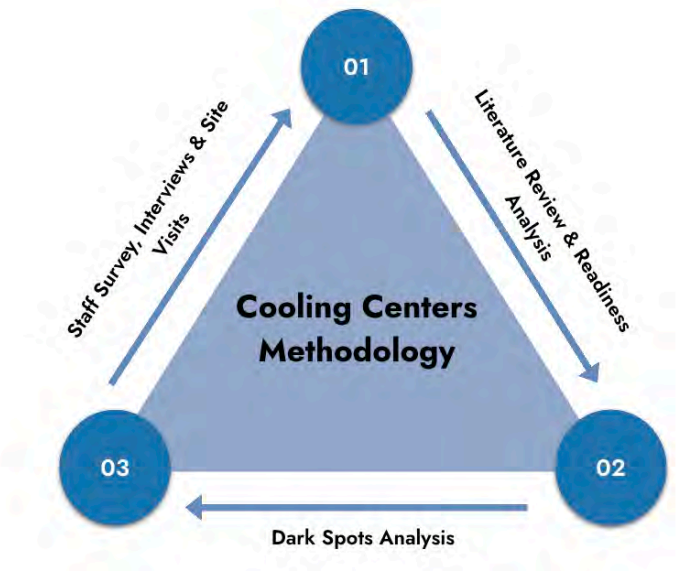
EXECUTIVE SUMMARY



Extreme heat is the greatest climate threat facing Los Angeles today. According to the 2021 Los Angeles County Climate Vulnerability Assessment, it is estimated that by mid-century there will be a tenfold increase in the frequency, severity, and duration of extreme heat events. As heat waves become more frequent and intense in Los Angeles, ensuring equitable access to cooling centers is imperative to protecting heat-vulnerable residents and communities who may otherwise lack access to cooling during a heat wave, particularly for unhoused residents and those without access to residential air conditioning. With these increasing extreme heat events in Los Angeles, and based on the literature highlighting the effectiveness of cooling centers as an adaptation strategy for extreme heat events, there is a need for greater research on formal and informal cooling centers within the city of Los Angeles.[1] Public cooling centers are an important part of the City's extreme heat resilience infrastructure, which includes residential air conditioning, shade and tree canopy, hydration stations, and other emergency response resources to mitigate heat risk and illness. Cooling centers are sites open to the public that generally consist of an indoor, air-conditioned space to provide respite from the heat. Ready LA County defines augmented cooling centers as "sites that are operated by the County or City partners with days and/or hours of operation that differ from that site's standard hours of operation or are added during specific heat events to expand Cooling Center services."[2] Cooling centers are an important adaptation strategy at a community level,

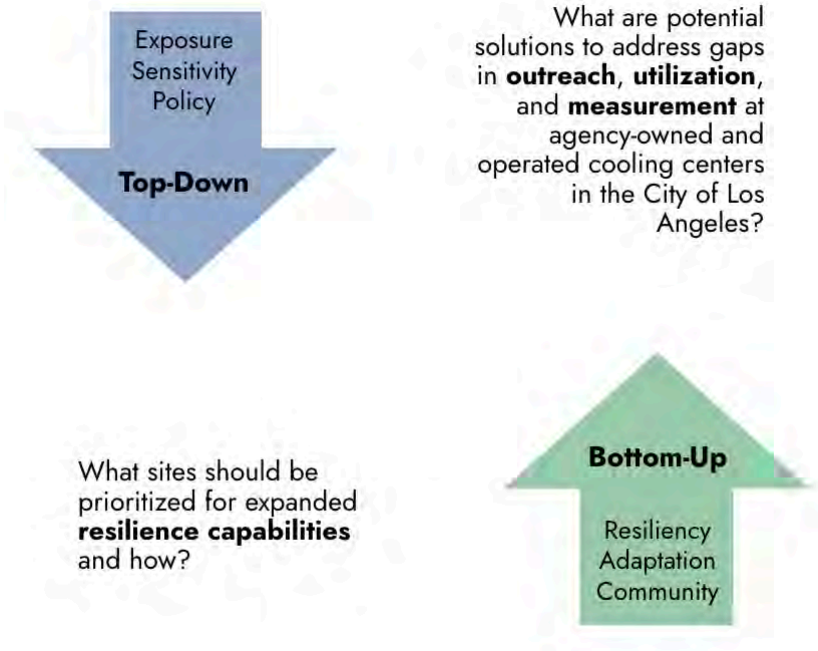
1 LA County Climate Vulnerability Assessment. (2021). LA County Chief Sustainability Office. https://ceo.lacounty.gov/wp-content/uploads/2021/10/LA-County-Climate-Vulnerability-Assessment-1.pdf

2 https://ready.lacounty.gov/heat/

because they are intended to provide free and accessible shelter to residents who do not have reliable sources of cooling during extreme heat events. Cooling centers are especially necessary for unsheltered residents and residents who do not have air conditioning in their homes, and can serve as a temporary intervention until all homes in Los Angeles are adequately cooled and weatherized against extreme heat conditions.

The main objective of this chapter is to explore the following research questions: *"What are potential solutions to address gaps in outreach, utilization, and measurement at agency-owned and operated cooling centers in the City of Los Angeles?"* and *"Which existing cooling center sites should be prioritized for expanded resilience capabilities and how?"* **(Figure 1)**. Throughout our research, we are centering the vision statement of our partner, the Los Angeles Climate Emergency Mobilization Office (CEMO), which aims for, "Co-created, democratized, healthy, thriving, climate-resilient communities for all in the City of Angels."

Figure 1: Our research questions explore the ways in which we can combine top-down and bottom-up adaptive measures to address extreme heat across the City of Los Angeles



This chapter encompasses a two-part analysis: 1) an analysis of existing cooling center conditions, capabilities, and readiness to determine how well current sites operate and are able to meet the needs of high-need communities, and 2) a Dark Spots Analysis to identify neighborhoods that are lacking in cooling center access and might

be prioritized for new cooling center or community resilience centers in the future. We are applying a mixed methods approach to our analysis of cooling centers within the City of Los Angeles, drawing on extensive engagement with various City departments and stakeholders currently or prospectively involved in cooling center policy.
Our evaluation of current center operations relies primarily on qualitative data in the form of surveys, interviews, and site visits, as well as quantitative analysis on usage across existing sites. Results and findings are organized into five themes: 1) Outreach and Partnerships, 2) Physical Site Characteristics, 3) Accessibility and Demographics, 4) Programming and Site Services, and 5) Cooling Center Usage. The assessment of cooling center "Dark Spots," or areas of Los Angeles that are in need of cooling centers, primarily relies on quantitative data. We use various vulnerability indicators, past temperature data, future heat projections, and existing cooling center locations to locate neighborhoods that are in greatest need of these facilities. Below are the Key Findings from our research.

#	Key Study Findings
1	City cooling centers see more visitors overall on extreme heat days, with notable increases in elderly and unhoused individuals as compared to other population groups
2	Air conditioning units may not work as well or break down during extreme heat days
3	Multilingual and targeted communications strategies are beneficial for conducting public outreach in diverse communities
4	Public safety is among the top concerns facing cooling center visitors and staff
5	Staff are interested and supportive of increased resiliency features and amenities at their sites
6	Unhoused communities require dignified cooling options that are accessible and tailored to their unique needs and experiences
7	A number of City-operated cooling centers are well-suited to become community resilience centers with increased funding for resiliency measures
8	Parts of the San Fernando Valley, East Los Angeles, South Los Angeles, and Harbor region exhibit high heat sensitivity and exposure that suggests an increased need for cooling center access

The collection and evaluation of both quantitative and qualitative data informs our final recommendations regarding gaps in existing cooling centers and the siting of new facilities. Through our qualitative and quantitative analysis of cooling centers across the City of Los Angeles, we have developed the following recommendations for CEMO and the City.

#	Key Study Recommendations
1	Expand beyond the traditional cooling center model toward a community resilience center model that supports climate-vulnerable communities
2	Expand access broadly to affordable and energy-efficient residential cooling for low-income and disadvantaged households
3	Develop relationships with unhoused communities and mutual aid organizations to co-develop heat responses that meet the needs of unhoused residents
4	Explore strategies to informally or semi-formally expand Los Angeles' cooling centers network to include various facility types
5	Prioritize new cooling and resilience center locations, existing center upgrades, and future activations in the South Valley, North Valley, and East Los Angeles
6	Streamline communications between City agencies, cooling center sites, and residents to optimize operations and increase community outreach
7	Ensure HVAC systems are maintained and upgraded at existing cooling centers, and offer portable cooling supplies such as handheld fans and cold compresses
8	Collect improved visitor data for existing cooling centers and bolster infrastructure and capabilities in facilities with higher rates of usage
9	Implement more individualized cooling solutions based on organization, site location, and needs of visitors

INTRODUCTION & BACKGROUND

Extreme Heat Response for Vulnerable Populations in Los Angeles

In 2020, a heatwave in Los Angeles brought several neighborhoods into triple-digit temperatures and resulted in over three deaths. Despite these conditions, fewer than 300 people visited one of the six cooling centers that were set up in the county.[3] Each cooling center averaged 11 visitors per day, except for a center located in South L.A., which had no visitors. In 2022, the city experienced a deadly "heat dome" event that persisted for nearly two weeks in the late summer. During this time, unhoused individuals without shelter from heat comprised a high proportion of reported fatalities from hyperthermia and heat stroke within Los Angeles County. While unhoused people make up less than .01% of the County's population, they accounted for over 40% of the County's heat-related deaths in the 2022 calendar year, with half occurring during the heat dome event alone.[4] Part of the City of Los Angeles' response was to activate 11 recreation centers that acted as augmented cooling centers across the city to help over 2,250 residents access shelter from the heat. However, advocates in Los Angeles have cited the need for increased access to cooling centers and outreach programs to save the lives of the city's unhoused residents during extreme heat events.[5]

Public officials from the City of Los Angeles typically advise residents to stay inside an air-conditioned space, avoid strenuous physical activity, and stay hydrated during a heat wave. However, not everyone can protect themselves equally from the dangers of extreme heat. Unhoused residents and outdoor workers often spend most (if not all) of the day outside, and with little protection from high temperatures and direct sunlight, are among the most heat-vulnerable populations. Some groups, such as children, seniors, and people with disabilities or pre-existing health conditions, are

3 Reyes, Emily Alpert. "L.A. Suffered Deadly Heat, Yet Chairs Sat Empty at Its Cooling Centers." Los Angeles Times, Los Angeles Times, 19 Sept. 2020

4 Lin, S. (2023, February 19)."'He baked': Heat waves are killing more L.A. homeless people who can't escape broiling sun." Los Angeles Times. https://www.latimes.com/california/story/2023-02-19/la-me-homeless-heat-deaths

5 Beckett, L. (2022). "'It's too hot': Los Angeles melts under its worst heatwave of the year." The Guardian. https://www.theguardian.com/us-news/2022/sep/02/los-angeles-extreme-heat-wave-emergency

predisposed to acute heat sensitivity due to their decreased bodily capacity to regulate thermal stress. People without access to health insurance or reliable health care are also more vulnerable to the adverse impacts of extreme heat.

Other factors, such as the built environment and building thermal performance, exacerbate disproportionate heat burden and exposure across the city. Neighborhoods lacking in tree canopy, shade structures, and parks are all predisposed to hotter temperatures than neighborhoods with more green space and trees, and many of these neighborhoods are in historically redlined areas.[6] Homes and buildings that lack air conditioning and insulation, which tend to be older rental units and mobile homes, can trap heat inside and feel hotter than outside temperatures on extremely hot days. These disparities in the built environment and thermal comfort have been found to coincide with racial and economic inequities across historically redlined and disinvested neighborhoods.[7]

Increasing extreme heat also exacerbates existing environmental injustices. Race and class differentiate health outcomes. The majority of residents in communities highly vulnerable to extreme heat in Los Angeles are Latino/Latinx. Communities of color living in disinvested neighborhoods have disproportionately less access to green space and more heat-absorbing surfaces in their built environment, which makes extreme heat worse. According to Dr. Melody Goodman, whose research seeks to understand the social risk factors that contribute to health disparities in urban areas, "Your zip code is a better predictor of your health than your genetic code."[8]

Los Angeles County Adaptive Capacity Assessment (ACA)

Across Los Angeles, there are a variety of ways in which residents adapt to stay cool during extreme heat events and hot days. The 2021 Los Angeles County Adaptive Capacity Assessment (ACA) defines adaptive capacity as "the ability of a community to respond to, recover from, and adapt to climate change hazards, using existing tools

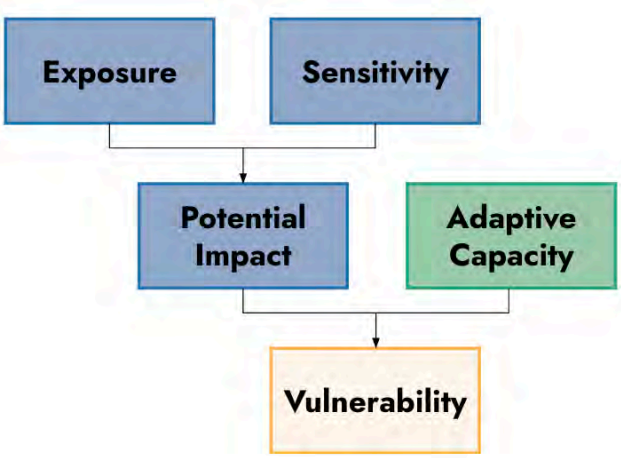
6 Wilson 2020, Nowak et al. 2022

7 Berberian, et al. (2022). "Racial Disparities in Climate Change-Related Health Effects in the United States." Current Environmental Health Reports. https://link.springer.com/article/10.1007/s40572-022-00360-w

8 Roeder, A. (2014, August 4). Zip code better predictor of health than genetic code. Harvard T.H. Chan School of Public Health. https://www.hsph.harvard.edu/news/features/zip-code-better-predictor-of-health-than-genetic-code/

resources, funding, and programs" **(Figure 2)**.[9] Among ACA respondents, the most common ways to adapt to extreme heat included using water to cool down (31%), such as staying hydrated, going to a community pool, or taking a bath and using an air conditioner to cool a room (25%). Only 11% of respondents reported taking steps to retrofit homes by adding insulation or installing air conditioning and only 10% reported planting trees. Additionally, only 10% sought shade when outdoors. Heat-vulnerable populations expressed a variety of barriers to cooling down. One respondent said, "I am a renter, not a homeowner, so I am not the one making these sorts of decisions for my apartment building. We are not even allowed to have a window AC unit as per our lease." Results from the ACA emphasize the need for improved adaptive capacity in the form of accessible heat protection, and signal the importance of public cooling centers as an option for residents to access heat refuge during high-heat days.

Figure 2: Diagram showing how impact and adaptive capacity determines vulnerability



Existing Cooling Center Operations in Los Angeles

With the establishment of CEMO and the Chief Heat Officer position, the City of Los Angeles is taking a holistic approach to addressing extreme heat and expanding measures to increase heat resilience and protection, particularly in frontline communities. Efforts are currently underway to improve the City's heat management systems that are essential to saving lives. For example, in response to the 2022 Heat

9 Los Angeles County Department of Regional Planning (2021, October 1). Adaptive Capacity
9 Assessment. Retrieved March 22, 2023, from "Adaptive Capacity Assessment - Los Angeles County, California." Los Angeles County Department of Regional Planning, Oct. 2021, https://planning.lacounty.gov/site/climate/wp-content/uploads/2021/12/Adaptive-Capacity-Assessment-Final-12092021.pdf.

Dome event, CEMO developed the Cool Spots LA app to provide information on the City's augmented cooling centers, hydration stations, and public pools all in one comprehensive map.[10] CEMO has also launched an annual "Heat Relief 4 LA" campaign to raise public awareness on the dangers of extreme heat and provide information on how residents can stay cool. Also, in 2022 and 2023, CEMO partnered with the Liberty Hill Foundation to co-host the Climate Equity LA workshop series to engage community-based organizations and residents and address how frontline communities experience climate inequities and extreme heat across the city.

Currently, CEMO is overseeing efforts to scale access to public cooling centers and improve their capacity to serve communities that rely on them most. The City of LA operates a network of public cooling centers that serve as a key component of the city's emergency heat response infrastructure, currently entailing 16 augmented cooling centers at select recreation centers and 72 library branches **(Figure 3)**. The City does not operate any stand-alone cooling center sites. In theory, public cooling centers are intended to provide daytime shelter for anyone seeking access to an air-conditioned space during extreme heat events and are a critical resource for unhoused residents, households who cannot access or afford air conditioning, or anyone else seeking temporary refuge from the heat. In particular, City-run cooling centers should be considered a safety net resource for residents lacking alternatives to indoor cooling during a heat wave;

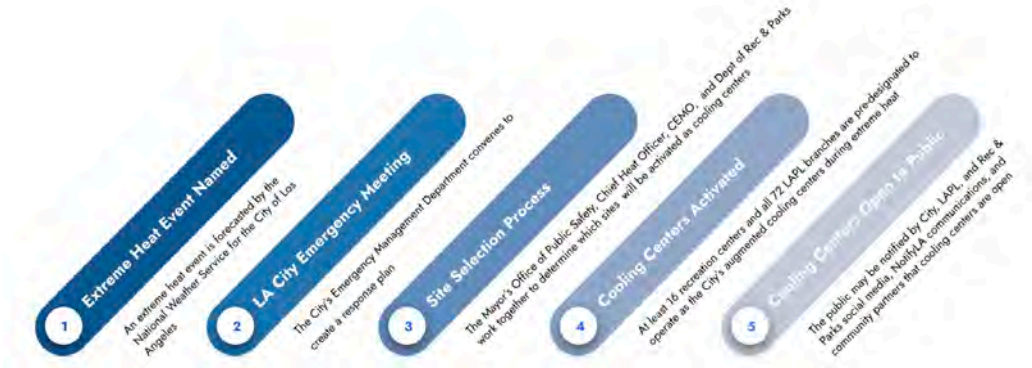
Figure 3: Various sites across the City of Los Angeles work together to be "activated" as cooling centers, including Rec & Parks Sites and LA Public Libraries

10 Cummens, P. (2022). "LA's New Chief Heat Officer Expands Cooling Centers Based on Equity Maps." ESRI. https://www.esri.com/about/newsroom/blog/los-angeles-chief-heat-officer-expands-cooling-centers/

They should not be considered a substitute for residential air conditioning or other installations to maintain safe temperatures inside homes.

According to CEMO, City-owned and operated cooling centers are designated public facilities that provide access to air conditioning, water, and restrooms, and retain a visitor capacity of at least 30 people. These official cooling centers are open during normal business hours and meet ADA accessibility requirements. Once an extreme heat event is forecasted by the National Weather Service, the City's Emergency Management Department convenes the Mayor's Office of Public Safety, Chief Heat Officer, CEMO, and Department of Recreation and Parks to develop a response plan and determine which recreation centers will be activated as cooling centers. During a heat emergency, all branches of the Los Angeles Public Library are also activated to serve as public cooling centers **(Figure 4)**. The City's extreme heat response team also coordinates outreach and communications strategies to keep the public informed about the forecasted heat wave and publicize official cooling center locations. Primary outreach channels include the City's extreme heat website, press releases, social media blasts, local news and radio stations, and NotifyLA, the City's emergency alert system.

Figure 4: During an extreme heat event in Los Angeles, the City follows a standardized process to activate its cooling centers for public use

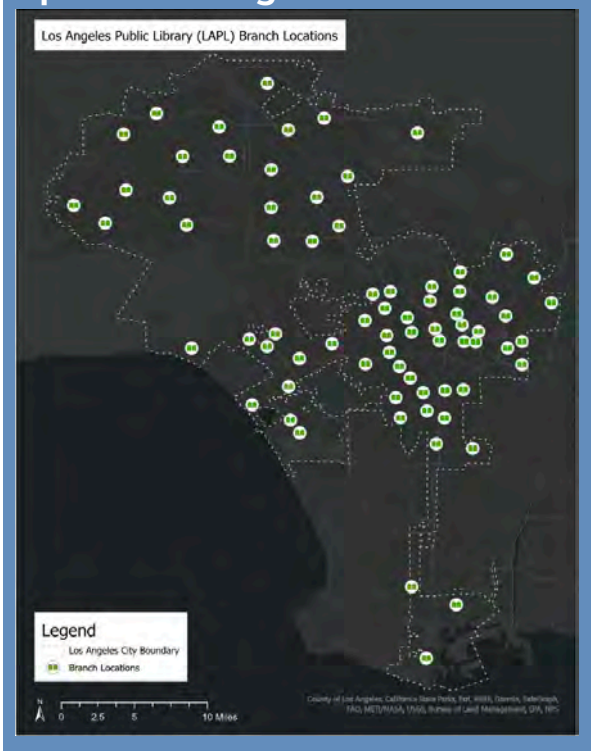


CEMO is also exploring ways to expand access to community resilience centers, although few exist in practice to date. In contrast to cooling centers, which focus primarily on providing air conditioning during heat waves, community resilience centers are trusted community sites that are designed to provide a host of emergency resources such as backup power, food and water, charging stations, and other social services during a heat emergency or other natural disaster.[11] According to the Urban Sustainability Directors Network, there are five key components to

11 Lou, Z. (2020). Resilience before disaster: The need to build equitable, community-driven social infrastructure. Goldman School of Public Policy.

creating resilience hubs: services and programs, communications, building and landscapes, power, and operations.[12] Services and programs are meant to promote social cohesion and community preparedness both during emergency and non-emergency periods. As of May 2023, CEMO has identified two public library sites in Hyde Park and Watts (described in our site visits analysis) that will potentially serve as pilot sites for the community resilience center model within the City's existing cooling centers network.

Figure 5: During a heat emergency, all 72 branches of the Los Angeles Public Library are also activated to serve as public cooling centers



Existing Cooling Centers and Dark Spots Analyses

Building on CEMO's extreme heat adaptation strategies and stated goal to prioritize cooling center access, the UCLA MURP Comprehensive Project team was commissioned to conduct an evaluation of existing City-owned and operated cooling centers. Working in close collaboration with CEMO, the Chief Heat Officer, Department of Recreation and Parks, Los Angeles Public Library, Emergency Management Department, Department of Water and Power, and other key stakeholders, our research team analyzed the use, capacity, and siting of the City's augmented cooling centers (16 recreation centers with expanded cooling center capabilities) and public library network (72 branches). All City of Los Angeles cooling centers are multi-functional facilities; the City does not currently operate any stand-alone cooling center sites. Our data collection and analysis has allowed us to examine the accessibility of existing cooling centers for heat-vulnerable populations, cooling center operations and performance on high-heat days, potential upgrades or improvements to best serve community members, and opportunities for further coordination across public agencies and community-based organizations to

12 Network, Urban Sustainability Directors. "Urban Sustainability Directors Network." USDN, https://www.usdn.org/resilience-hubs.html.

expand reach and utilization.

In addition, our team examined potential "Dark Spots" that likely exist across the City's current cooling center network to identify neighborhoods that may not have adequate access to cooling center sites. Taken together, these dual research efforts analyze possible gaps in the City's existing cooling center infrastructure as well as neighborhoods that may be lacking in cooling access altogether.

Working in close collaboration with CEMO, the Chief Heat Officer, Department of Recreation and Parks, Los Angeles Public Library, Emergency Management Department, Department of Water and Power, and other key stakeholders, our research team analyzed the use, capacity, and siting of the City's augmented cooling centers (16 recreation centers with expanded cooling center capabilities) and public library network (72 branches).

Literature Review: Understanding Heat Exposure and Cooling Access to Create Heat Resilience Strategies

Our study focuses on evaluating the City of Los Angeles' public cooling centers network to understand their current operations, effectiveness in serving priority populations, as well as opportunities for improvement in their service provision and future siting. Cooling centers should be activated by local government agencies with the intention of providing heat relief and safety to members of the public who need it most. When considering the need for cooling centers, we must consider the disparities that force some residents to rely on public heat refuges more than others. In particular, cooling centers are more likely to serve those who lack other means of indoor cooling, such as unhoused residents and households without access or ability to pay for in-home air conditioning. We have also reviewed prior literature on cooling center access and performance, as well as the community resilience center model, to understand how public cooling centers can be optimized to serve communities that rely on them most. There is generally more of a focus in the academic literature on cooling center prevalence and location, similar to our Dark Spots Analysis, than on usage and potential transition to community resilience centers.

Priority Populations for Cooling Protections

Without access to reliable shelter, unhoused individuals are the most heat-burdened population group in urban areas. Schwarz et al. analyzed data on emergency department visits of unhoused individuals in San Diego County, California in 2012 to 2019, between the months of May and September.[13] Unhoused individuals are defined as those who lack access to physical shelter or live in shelter conditions that do not meet basic health and safety standards. California's unhoused population is acutely vulnerable to extreme heat due to the population's increased risk of preexisting conditions, mental illness, and substance use, as well as the region's warming climate and housing crisis. Specific to San Diego County, the likelihood of hospitalization for unhoused individuals was found to increase during heat waves, with younger individuals (18-44 years old), older individuals (65 years or older), and individuals that required "psychiatric consultation" found to be more likely to experience hospitalization. "Overall, persons experiencing homelessness were more vulnerable to heat waves than were non-homeless persons." Noting that an individual's mental health may impair their ability to seek refuge at a cooling center or stay hydrated, the study suggests that targeted outreach teams that include psychiatrists could assist unhoused residents to stay safe during extreme heat events. Overall, the study concluded that devising appropriate heat protections for unhoused individuals may be more difficult to identify when compared to other heat vulnerable groups. Cities and health care systems can look to early evidence from this study when developing heat response systems that prioritize the specific needs of unhoused residents.

When it comes to individuals with housing, building thermal performance, and residential cooling can still mean the difference between a safe home or a heat trap for inhabitants. Renters without cooling face compounding heat risks since landlords retain the power to decide whether or not to install air conditioning or weatherization in their units. Absent any habitability standards or building codes that would establish a maximum indoor temperature in rental units, landlords are not legally obligated to ensure rental units are equipped with cooling in Los Angeles. Older housing units constructed before universal building regulations were enacted in California are also at increased risk for hazardous indoor heat, in addition to mobile homes that typically

13 Schwarz, L., et al. (2022) "Heat Waves and Emergency Department Visits Among the Homeless, San Diego, 2012–2019." American Journal of Public Health. https://ajph.aphapublications.org/doi/full/10.2105/AJPH.2021.306557

lack insulation and weatherization.[14]

Nahlik et al., 2016 examined the thermal performance of various building types in Los Angeles, California and Phoenix, Arizona.[15] Their analysis concluded that buildings in the oldest neighborhoods of Los Angeles and Phoenix demonstrated the worst thermal performance. Apartment buildings were found to include 7 of the 10 worst performing building types, compared to 3 of the 5 best types among commercial buildings. Overall, the worst performing census tracts were concentrated with both single-family homes and multi-family units that were built before 1960, marked by thinner windows, walls, and less insolation than newer housing units. The study suggests that public officials in each city should prioritize heat-vulnerable areas for building retrofits that improve building envelopes, as determined by building thermal performance and projected temperature increases. Specific to Los Angeles, this study found that insulated, double-pane windows alone could drastically curb the rate at which indoor temperatures rise.

Considering the relationship between in-home and out-of-home cooling options, Fraser et al. conducted a study exploring the connection between residential cooling and accessibility to public cooled spaces in Los Angeles County, California and Maricopa County, Arizona.[16] Fewer than 50% of households in LA County were found to have central air conditioning (CAC), with a skew toward hotter regions of the county. In contrast, Maricopa County (where the City of Phoenix requires cooling in rental units[17]) was found to have a 95% residential CAC saturation rate. In mapping publicly-available cooled spaces, the researchers defined three categories: official cooling centers, libraries, and public commercial spaces. To measure household accessibility, they conducted an analysis based on walking time, walking speed, and existing street networks. They found that official cooling centers would serve only about 3% of all residences in LA County and only 2% in Maricopa County. However, census tracts in LA County scored higher in accessibility to any cooled public space overall, largely due to a higher prevalence of commercial space when compared to Maricopa County. The researchers recommended official cooling centers to be sited based on areas of

14 Gallarza, M. et al. (2022). "Protecting Californians with Heat-Resilient Homes." UCLA Luskin Center for Innovation.
15 Nahlik, M, et al. (2016). "Building Thermal Performance, Extreme Heat, and Climate Change." American Society of Civil Engineers.
16 Fraser, A. et al. (2016). "Household accessibility to heat refuges: Residential air conditioning, public cooled space, and walkability." Urban Analytics and City Science.
17 Phoenix City Code, Sec. 39-5.

greatest need and with consideration of available transportation options for residents.

Cooling Center Access & Effectiveness

Although public cooling centers serve as a common community resource during heat waves, less has been documented on how effectively they are able to serve heat-burdened communities. Bautista et al. analyzed cooling center use, accessibility, and demographics in Los Angeles County through mobility data[18]. Two types of cooling centers were defined: formal cooling centers that include public libraries and parks operated by local municipalities, and informal centers such as malls and grocery stores that provide indoor cooling as a secondary function of their primary operations. To explore patterns of occupancy and transportation on extreme heat and non-extreme heat days, the researchers extracted vulnerability indicators from the mobility data to determine if target populations were utilizing cooling centers in Los Angeles County. Based on their findings, the researchers recommended increased public communication on cooling centers, improved integration of cooling centers in heat mitigation plans, and public transportation access as a key evaluation variable in the County's efforts to improve and expand cooling center access.

Derakhshan et al. also performed an assessment of cooling centers and heat mitigation through mobile phone use in Los Angeles County. By mapping mobile phone use, researchers were able to conclude that 20% of the sample population in LA County has used formal or informal cooling centers during extreme heat days, with 90% using informal cooling centers. Overall, shopping centers and malls were leveraged most frequently as informal cooling centers. Informal, air conditioned spaces like these provided respite for vulnerable residents on extreme heat days without the need to pay for entry or service fees. Researchers found that the use of formal cooling centers is more localized than that of informal cooling centers: visitors tend to go to formal centers if they are located closer to their homes. Interestingly, cooling centers of all types in "walkable" locations did not record a higher number of visitors on extreme heat days. During extreme heat events, cooling center access via air conditioned transit may be favorable to walking outside directly exposed to the heat. Recommendations included improved public communication and advertising for cooling centers, increased collaboration between county and city partners, and

18 Bautista, T.N. Bouwman, M. Huang, L. Lee, L. Tarczynski, J. Wahagheghe, I. Zeng, X. (2022). Smart-phone locations reveal patterns of cooling center use during extreme heat in LA county. University of California, Los Angeles. Institute of the Environment and Sustainability.

accessing transit accessibility when evaluating or planning for new cooling center sites. Researchers also suggest incentivizing commercial spaces with air conditioning to allow use by vulnerable residents on extreme heat days, regardless of their status as a paying customer.

The New York City Comptroller's report, Overheated, Underserved: Expanding Cooling Center Access, focuses on cooling center access during a July 2022 heat wave in NYC.[19] Using data from New York City's Cooling Center Finder, the report investigates inequities in the city's cooling center accessibility. Six types of cooling centers were identified: Community Centers, Senior Centers, Cornerstone Programs (specific to NYC), Libraries, Schools, and Other. The Comptroller's Office calculated Heat Vulnerability Index (HVI) scores for each of the city's 59 community districts, analyzing the geographic distribution of cooling centers by calculating the number of cooling centers per 100,000 people in every borough. The report also analyzed hours of operation, and found that 30% of cooling centers closed before 4pm, although peak heat typically occurs between the hours of 3pm-4pm. Half of the cooling centers were closed on Saturdays and 83% were closed on Sundays, revealing limited weekend accessibility to the city's cooling centers. The Comptroller's Office provided both short and long term recommendations including integrating sustainability, wheelchair accessibility, expanding cooling centers in underserved communities, expanding hours of operation and increasing cooling center outreach to the community.

A primary objective of the research in this chapter attempts to address the gap in cooling center evaluation for the City of Los Angeles. Widerynski et al. noted that most research surrounding cooling centers has prioritized accessibility of cooling centers, but has often failed to evaluate cooling center performance and effectiveness, which go hand in hand.[20] The study investigated cooling center usage data to reveal important obstacles that prevent public knowledge and usage, including limited transportation, work conditions, inability to leave home, pets, stigma about who cooling centers are intended for and lack of experience at a cooling center. It concluded by identifying three major implementation areas: setting characteristics

19 Lander, B. New York City Comptroller. (2022). Overheated, underserved: Expanding cooling center access. Bureau of Policy and Research.

20 Widerynski, Stasia & Schramm, Paul & Conlon, Kathryn & Noe, Rebecca & Grossman, Elena & Hawkins, Michelle & Nayak, Seema & Roach, Matthew & Hilts, Asante. (2017). The use of cooling centers to prevent heat-related illness: summary of evidence and strategies for implementation of climate and health technical report series climate and health program, Centers for Disease Control and Prevention. 10.13140/RG.2.2.32267.59688.

(e.g., geography, built environment, public transit access), population characteristics (e.g., age, race, housing status), and intervention characteristics (e.g., cooling center locations, public outreach campaigns, on-site amenities).

Community Resilience Centers

Community resilience centers, also known as resilience hubs, have emerged as a growing conceptual solution to address an array of neighborhood needs during crisis and non-crisis periods, all under one roof. While most resilience centers include a number of common features, such as air conditioning, backup energy sources, and social programs, the concept itself can vary in its approach and application within a specific community. Literature on community resilience centers is limited as the concept is still largely nascent in the climate response and disaster preparedness field, and few resiliency centers have been built, much less established and evaluated for effectiveness.

In Lou's Resilience Before Disaster, resilience hubs are defined as physical institutions that offer space for community members to gather, organize, access resilience-building social services on a daily basis, and provide response and recovery services in disaster situations such as wildfires, heat waves, and power outages.[21] This study found that communities need additional resources to address disparate impacts of climate change, and resilience hub networks can help bridge this gap. Resilience hub networks were described as comprehensively delivering local programs and public services to meet community-identified resilience needs. The COVID-19 pandemic further intensified the need for comprehensive community resilience and a robust public sector to build social cohesion.

Key programmatic recommendations include:

- Fund resilience hub development
- Establish resilience hub networks
- Invest in the home care workforce as the frontline of in-home resilience
- Rebuild public sector workforce
- Improve emergency response coordination to protect vulnerable communities

21 Lou, Z. (2020). Resilience before disaster: The need to build equitable, community-driven social infrastructure. Goldman School of Public Policy.

To establish and improve resilience hubs networks, the study recommends:

- Conduct preliminary cost analysis
- Develop process to target areas based on need
- Conduct further research on governmental structure and establish network facilitation role Develop a planning and governance model

These recommendations have helped inform our motivation to expand community resilience centers across the City of Los Angeles.

UCLA Master of Public Policy Student Research Report

Parallel to our study, Master of Public Policy (MPP) candidates at UCLA Luskin worked with CEMO on a separate but complementary report, focusing on policy options that address heat inequities in frontline communities. The report, prepared by Hana Abdelatty, Dimitri English, Adan Garcia, Selena Melgoza, and Austin Mendoza, makes mention of cooling centers and includes the expansion of the City of Los Angeles' resilience center network as one of several policy recommendations. Like our research team, the group used a mixed methods approach with major data collection strategies including focus groups and a community survey. Seven focus groups were conducted with 68 total participants from community-based organizations (CBOs). "During the focus groups, participants shared their knowledge and experiences of existing community heat adaptation resources, community health challenges related to extreme heat, and potential policy options that would help their community during heat waves."[22] Participating CBOs included Black Women for Wellness, Central American Resource Center (CARECEN), Comunidades Indígenas en Liderazgo (CIELO), Fernandeño Tataviam Band of Mission Indians, Labor Community Strategy Center, Los Angeles Black Worker Center, and TRUST South LA.

The most common topics of discussion during the focus groups were at-home heat interventions, green spaces, and the adverse health effects of extreme heat. Although cooling centers were brought up by the research team, responses to them were lukewarm. "Many community members were unaware of existing resilience and cooling centers. Participants generally valued the potential benefits that resilience centers could bring to their communities but preferred the City provide resources for

22 Abdelatty, Hana, et al. Los Angeles, CA, 2023, Turning Down the Heat: Addressing Heat Inequities of Frontline Communities in Los Angeles.

them to stay cool and healthy at home."[23] Cooling centers were referred to as a "band-aid solution" and their limited hours of operation, inaccessibility via transportation, rules about pets, and levels of accessibility for older adults were also points of concern.

The survey distributed by the research team also touched on cooling centers. A respondent wrote, "I feel like there is no awareness about cooling centers and it is unheard of here. I've not had a conversation about cooling centers in my whole life living in Los Angeles."[24] The MPP research team concluded that public communications about available resources on extreme heat days are lacking, coinciding with our team's findings. The survey also asked about community members' priorities with regard to heat adaptation resources. Resilience hubs and cooling centers ranked fifth, while the top choices were air conditioning and fan distribution, more green space (parks, gardens, trees), hydration stations, and shaded bus stops and other shade structures.

Despite relatively low levels of enthusiasm from community members about cooling and resilience centers, the MPP research team determined that these types of sites "can increase distributive equity by providing a cool environment for frontline community members who do not have access to cooling in their homes."[25] The team points out that converting existing facilities to temporary resilience centers makes more sense financially than constructing new ones but adds that the resilience center network will need to expand beyond City-owned facilities in order to best support frontline communities. They ultimately recommend the expansion "of the resilience center network as long as it complements equally funded at-home interventions"[26] and make three recommendations regarding the process of expansion:

- Partner with trusted CBOs to support a network of community-owned and community-implemented resilience centers
- Ensure that resilience centers include heat adaptation resources, general City resources, and activities for frontline community members
- Provide resilience centers in areas with relatively large unhoused communities to specifically distribute resources based on the stated needs of people experiencing homelessness

23 Ibid.
24 Ibid.
25 Ibid.
26 Ibid.

The UCLA MPP team's research provided important insights and helped inform our approach, findings, and recommendations. Given the alignment of both reports, we hope CEMO will be able to use them in conjunction.

DATA & METHODS

In this chapter, we explore the following research questions and their implications for future extreme heat planning and preparedness in the City of Los Angeles: *"What are potential solutions to address gaps in outreach, utilization, and measurement at City-owned and operated cooling centers in Los Angeles?"* and *"Which existing cooling center sites should be prioritized for expanded resilience capabilities and how?"* This two-part study encompasses an analysis of Existing Center Conditions, Capabilities, and Readiness Analysis to understand how well cooling centers currently operate and serve high-need communities, and a Dark Spots Analysis to identify areas of Los Angeles that may require increased access and investments in new cooling centers/community resilience hubs.

Building on past research, our study applies a mixed methods approach to our analysis of cooling centers in order to integrate multiple data types. A mixed methods approach allows us to balance singular data type weaknesses, focus on each data type's advantages and investigate our research question in depth. The collection and evaluation of both quantitative and qualitative data has informed our final recommendations to address gaps in existing cooling centers and the siting of new facilities.

With regard to the assessment of cooling center gaps and resilience center readiness, both our quantitative and qualitative methods seek to identify shortcomings across the five themes: Outreach and Partnerships, Physical Site, Accessibility, Programming and Site Services, and Cooling Center Usage and Demographics. These themes have been determined based on a review of functions generally deemed foundational to the structure and function of community resilience centers. The assessment of cooling center "Dark Spots," or areas of Los Angeles that are in need of cooling centers, primarily relies on quantitative data. Using various social vulnerability indicators, past temperature data, future heat projections, and existing cooling center locations, we attempt to locate neighborhoods that are in greatest need of these facilities.

Table 1 below outlines the connections we are making with our mixed method approach across quantitative and qualitative data types, acting as a guide for our analysis. The table is organized by category and related quantitative and qualitative data within each theme.

Table 1: Thematic Mixed Method Approach

Category	Quantitative Data	Qualitative Data
Outreach & Partnerships	N/A	• Identifying current partnerships with CBOs • Identifying if there is a need for improved outreach and communication • Identify what groups outreach is catered towards and its success • Identify outreach methods to community members
Physical Site	• On extreme heat days, how many people could a designated space at the facility accommodate?	• Identifying if there is a need for improvements to the physical building (AC, ADA, more seating, etc.) • Identify if there is a need for more shuttle and transportation options to the site • Examining hours of operation • Examining AC functionality
Accessibility	N/A	• ADA accessibility and compliance • Identifying if there is a need for improved communication via language accessibility • Identify if languages spoken by visitors are supported by the site • Hours of operation • Other potential constraints in accessing sites such as transportation limitations and safety • CPR and first aid • Pet friendly

Programming & Site Services	N/A	• Identify if there is a need for improvement in cooling center programming • Identifying a possible need for extended hours of operation • Examining what activities are observed during extreme heat days at cooling centers • Changes in number of staff needed on extreme heat days versus regular programming • Staff training and frequency on cooling center operations and first aid
Cooling Center Usage & Demographics	• Approximately how many people sought refuge at activated cooling center locations during the Summer 2022 Heat Wave? • Where were cooling centers located in relation to average maximum surface temperatures during the Summer 2022 Heat Wave?	• Examining current hours of operation. • Looking at potential changes in visitor activities at cooling centers during extreme heat days • During extreme heat days, changes at cooling centers in demographics, frequency and number of visitors

Existing Center Conditions, Capabilities, and Readiness Analysis

To assess existing cooling center conditions, capabilities, and readiness to transition into resilience centers, we collected and analyzed information across five important center attribute categories: Outreach and Partnerships, Physical Site, Accessibility, Programming and Site Services, and Cooling Center Usage. This quantitative approach was informed by conversations with several City of Los Angeles departments: Los Angeles Department of Water and Power (LADWP), Climate Emergency Mobilization Office (CEMO), Los Angeles Public Libraries (LAPL), and the Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC). Reviews of existing literature and resources related to cooling and resilience centers were also integral to developing this approach.

The nature of our cooling center staff survey (detailed below) allows for the easy quantification of information from individuals who operate cooling centers, facilitate programming, and interact with those in need of relief from extreme heat. Survey responses were collected from both RAP sites and LAPL locations, allowing us to better understand site specific conditions and capabilities. Specific questions include:

- Is your site ADA compliant and accessible?
- Are you, or any of your staff, trained in emergency response (e.g. first aid, CPR)?
- What are common languages spoken at your site by visitors, and are they supported by staff?
- Is your site pet-friendly (including non-service animals) during normal operating hours and during extreme heat days?

Our team was also able to conduct additional quantitative research using data provided by LAPL and RAP. In the categories of Physical Site and Cooling Center Usage, we quantitatively analyzed meeting, community, and or conference room capacities and usage patterns from the Summer 2022 heat wave (August 31, 2022 to September 9, 2022) to better understand visitorship patterns across the city.

Physical Site:

- On extreme heat days, how many people could a designated space at the facility accommodate?

Cooling Center Usage:

- How many people sought refuge at activated cooling center locations during the Summer 2022 Heat Wave?
- Where were cooling centers located in relation to average maximum surface temperatures during the Summer 2022 Heat Wave?

Dark Spots Analysis

CEMO and other City departments responsible for providing relief for Los Angeles residents during extreme weather conditions, including the Los Angeles Public Library system (LAPL) and the Department of Recreation and Parks (RAP), want to better understand which communities are most vulnerable to the impacts of extreme heat and do not have adequate access to cooling centers. Our team conducted a geospatial suitability analysis ("Dark Spots Analysis") in order to identify and visualize areas of the city that are most in need of new cooling centers and lack sufficient access. In this phase of our research, we created an index specific to cooling centers that considers both environmental (future heat projections and building age) and human sensitivity (social vulnerability indicators and 2022 homeless count data) criteria.

To factor future heat projections into our analysis, we used UCLA's California Healthy Places Index (HPI): Extreme Heat Edition to spatially visualize the projected number of days over 90 degrees Fahrenheit between 2035 and 2064 by census tract.[27] Tracts predicted to have a greater number of days over 90 degrees Fahrenheit rank higher in the Dark Spots Analysis.

Alongside the Emergency Data and Bus Shelter groups collaborating in this report, we relied on the Los Angeles County Climate Vulnerability Assessment's (CVA) because it contains a wide variety of social vulnerability variables related to extreme heat and ensures consistency across this report. This report was published at the same time as the ACA, both by LA County in October 2021.

In partnership with community organizations, the Los Angeles County's Chief Sustainability Office developed the tool and its accompanying report. Published in October 2021, the CVA "builds on a solid foundation of climate research to analyze vulnerability in Los Angeles County - examining climate risks to [...] diverse people and places, including populations with heightened susceptibility to climate impacts,

27 California Healthy Places Index: Heat Edition. (n.d.). UCLA Luskin Center for Innovation. Retrieved May 21, 2023, from https://innovation.luskin.ucla.edu/climate/heat/

across unincorporated communities and 88 municipalities."[28] The assessment discusses physical vulnerability, cascading impacts, and five climate hazards: extreme heat, wildfire, inland flooding and extreme precipitation, coastal flooding, and drought. Most relevant to our efforts is the social vulnerability assessment, which outlines 29 social sensitivity indicators. **Table 2** below lists those the variables we identified to be most relevant to cooling centers, which have been incorporated into our Dark Spots Analysis.

Table 2: Identifies indicators from the Los Angeles County Climate Vulnerability Assessment (CVA) that are most relevant to cooling centers and incorporated in our dark spots analysis

Social Vulnerability Indicator	Definition	Cooling Center Relevance	Source
Black	% of people identifying as non-Hispanic black or African American	Vulnerable urban communities tend to have higher concentrations of Black people	2018 ACS
Children	% of people 18 and under	Children are prone to negative health impacts of extreme heat	2018 ACS
Disability	% of people with mental/physical disability	People with health conditions and disabilities are prone to negative health impacts of extreme heat	2018 ACS
Hispanic Latinx	% of people identifying as Hispanic or Latinx	Vulnerable urban communities tend to have higher concentrations of Hispanic or Latinx people.	2018 ACS
Households without vehicle access	% of households without personal vehicle access	People without personal vehicles are limited in terms of mobility	2018 ACS

28 LA County Vulnerability Assessment. (2021). Los Angeles County. https://ceo.lacounty.gov/wp-content/uploads/2021/10/LA-County-Climate-Vulnerability-Assessment-1.pdf

Median income	Median household income of census tract	Lower-income households are less likely to be able to afford A/C and increased utility bills	2018 ACS
Mobile homes	% of occupied housing units that are mobile homes	Mobile homes do not withstand extreme heat well and have poor thermal performance. Mobile homes are often located in high heat exposure areas	2018 ACS
No health insurance	% of people without health insurance	People without insurance might be unaware of preexisting conditions and less likely to seek care for symptoms due to heat exposure	2018 ACS
Older adults	% of people 65 and older	Older adults are sensitive to mortality and negative health impacts of extreme heat	2018 ACS
Older adults living alone	% of people 65 and older living alone	Older adults living alone are especially sensitive because they are socially isolated	2018 ACS
Outdoor workers	% of workers in agriculture, fishing, mining, construction, etc.	Outdoor workers have greater exposure during extreme heat events and jobs that require physical exertion.	2018 ACS
Rent burden	% of households paying more than ⅓ of monthly income	People who are rent burdened are less likely to be able to afford A/C and increased utility bills.	2018 ACS
Transit access	% of people within ½ mile of major transit stop	People without adequate transit access are limited in terms of mobility.	HPI, SCAG

We also intended to use the CVA to examine the impact of the physical environment on climate hazards and offer a comprehensive and accurate read of extreme heat risks and cooling center needs. However, we were unable to obtain underlying data for the CVA's community adaptive capacity indicators, which include proximity to heat refuge (cooling centers and other cool indoor public and private locations), park access, thermal building performance, tree canopy, and permeable surfaces. Instead, we relied on American Community Survey data on building age to account for these gaps, finding that Census tracts with a greater proportion of buildings built before 1969 rank more highly as being in need of cooling centers in our analysis.

An important social sensitivity indicator omitted from the CVA is homelessness. "Although the unhoused population represents about 70,000 of Los Angeles County's more than 9.8 million people, they accounted for nearly half (5 in 12) of deaths from heat illness or heat exposure in 2022, according to data from the Los Angeles County Coroner's Office."[29] Unhoused residents are an essential group to include in our study given the serious dangers posed during extreme weather events to individuals living outside or without access to permanent shelter. Accordingly, our team used the Los Angeles Homeless Services Authority's (LAHSA) most recent homeless count data from 2022 to account for the absence of an unhoused social sensitivity indicator in the CVA, while keeping in mind that the dataset might not capture the transient nature of this community. When factored into our suitability study, areas of the city with higher counts of unhoused individuals will rank more highly.

In overlaying LAPL locations and augmented cooling center locations, we are able to identify Dark Spots in the cooling center network and provide CEMO with a visual representation of high-need communities and potential areas for cooling or resilience center siting and investment. Using the Suitability Modeler tool in ArcGIS Pro, which identifies optimal locations for siting or preservation,[30] we input our selected criteria and assigned each a weight (a percentage out of 100%). The modeler uses the weights, or levels of importance assigned to each criteria, to identify recommended locations – in this case, areas in need of cooling centers. Time constraints did not allow

29 Lin, S. (2023, February 19). Heat waves are killing more L.A. homeless people. Los Angeles Times. https://www.latimes.com/california/story/2023-02-19/la-me-homeless-heat-deaths

30 ArcGIS Pro 3.1. (n.d.). What is the Suitability Modeler? Retrieved May 8, 2023, from https://pro.arcgis.com/en/pro-app/latest/help/analysis/spatial-analyst/suitability-modeler/what-is-the-suitability-modeler.htm

us to thoroughly and scientifically determine the weights for each category. Therefore, our analysis is weighted as evenly as possible. The environmental criteria (future heat projections and building age) and human sensitivity criteria (social vulnerability indicators and 2022 homeless count data) each account for 50% of the score. Those portions are then divided evenly by the number of criteria in them - five in the case of environmental criteria and 14 in the case of human sensitivity criteria. Areas of Los Angeles that meet more of the criteria emerged as being in need of better access to cooling centers and potential resilience centers.

Table 3: Breakdown of the equal weighting of environmental and human sensitivity criteria in the ArcGIS Suitability Modeler used to generate the Dark Spots Analysis

Dark Spots Analysis Criteria	Weight (%)	Cooling Center Relevance Source
HPI Heat Projections	10%	Census tracts projected to have a greater number of 90+ degree days should be prioritized for greater cooling center access and availability because that is where high temperatures will be experienced most acutely
ACS Building Built 1939 or Earlier	10%	Census tracts with buildings constructed prior to 1969 should be prioritized for greater cooling center access and availability due to poorer levels of thermal performance and a lower likelihood of being equipped with air conditioning
ACS Building Built 1940-1949	10%	
ACS Building Built 1950-1959	10%	
ACS Building Built 1960-1969	10%	
13 CVA indicators	46.41% (3.57% each)	All social vulnerability indicators are weighted equally
Homeless Count Data	3.57%	
TOTAL	**100%**	

We also spatially visualized the overall social vulnerability scores from the CVA in order to gauge if and how the results of our index differ, if at all from the County's assessment.

Qualitative Methods and Data: Staff Survey Survey Background and Key Themes

In order to explore potential solutions to address gaps in outreach, utilization and measurement at City-owned and operated cooling centers, we first gathered data through the use of pre-structured surveys for cooling center site staff. The survey is designed to measure characteristics of cooling centers through nineteen questions developed in line with our themes. The structure of the survey is primarily composed of a multiple choice or checkbox format with structured responses. When applicable, the answer options also contain a free response or "Other" option to capture free responses. The target survey respondents were cooling center site staff, or those involved in cooling center-related work from the Los Angeles Public Library (LAPL) and Department of Recreation and Parks (RAP). The survey is intended to go beyond existing numerical visitor counts to assess key themes of Programming and Site Services, Physical Site, Cooling Center Usage and Demographics, Accessibility and Outreach and Partnerships.

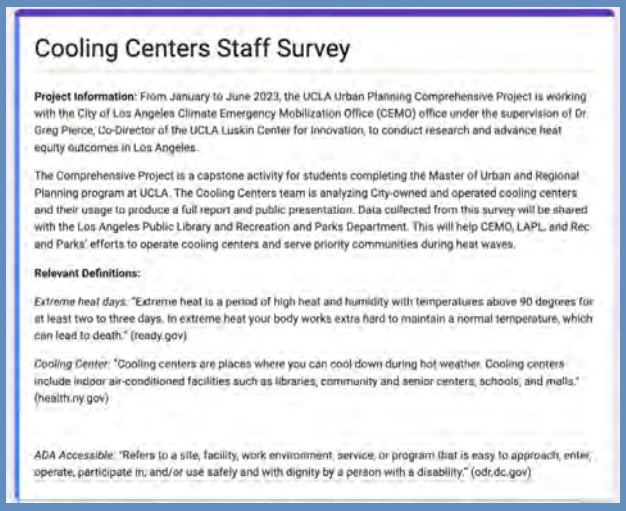
Survey Questions and Answer Options

Two separate surveys were distributed to LAPL and RAP, per each organization's requests. Although we distributed two separate surveys and one survey omitted a few questions, omitted questions have already been answered, and the surveys remain consistent across both groups. As shown in Figure 6, the survey begins with an introduction on the motivation behind collecting survey data and provides relevant definitions for "Extreme Heat Days," "Cooling Centers" and "ADA Accessible." The final part of the background section contains two questions about respondents' site location and job position at the site.

The survey continues with 15 pre-structured questions, with two questions related to Programming and Site Services, two questions on Physical Site Characteristics, five questions on Cooling Center Usage and Demographics, three questions on Accessibility, and three questions on Outreach and Partnerships. The table (found in the appendix) displays questions by theme, highlights our analysis plans, and shows distribution, as any organization not checked off under the 'Distribution' category has not been distributed as a direct survey question because the organization has answered the question outside of the survey. The wording of answer options for respondents is an integral part of the survey design process in our methodology as

they can impact respondents' selections. Because the survey is primarily composed of pre-structured, multi-select questions, we also included open-ended questions to allow space for respondents to note any additional comments or questions not already addressed. Although we have categorized question types, many questions have the potential to fall in multiple categories based on responses, which we have taken into account in our data analysis. Lastly, the end of the survey provides respondents with the option to share their contact information for a follow-up interview regarding their experience working at a cooling center during extreme heat days.

Figure 6: The Cooling Centers Staff Survey was distributed the week of March 20th to Los Angeles Public Library and Recreation & Parks. Respondents had approximately two weeks to complete the survey. The survey closed on May 2nd, 2023



Cooling Centers Staff Survey

Project Information: From January to June 2023, the UCLA Urban Planning Comprehensive Project is working with the City of Los Angeles Climate Emergency Mobilization Office (CEMO) office under the supervision of Dr. Greg Pierce, Co-Director of the UCLA Luskin Center for Innovation, to conduct research and advance heat equity outcomes in Los Angeles.

The Comprehensive Project is a capstone activity for students completing the Master of Urban and Regional Planning program at UCLA. The Cooling Centers team is analyzing City-owned and operated cooling centers and their usage to produce a full report and public presentation. Data collected from this survey will be shared with the Los Angeles Public Library and Recreation and Parks Department. This will help CEMO, LAPL, and Rec and Parks' efforts to operate cooling centers and serve priority communities during heat waves.

Relevant Definitions:

Extreme heat days: "Extreme heat is a period of high heat and humidity with temperatures above 90 degrees for at least two to three days. In extreme heat your body works extra hard to maintain a normal temperature, which can lead to death." (ready.gov)

Cooling Center: "Cooling centers are places where you can cool down during hot weather. Cooling centers include indoor air-conditioned facilities such as libraries, community and senior centers, schools, and malls." (health.ny.gov)

ADA Accessible: "Refers to a site, facility, work environment, service, or program that is easy to approach, enter, operate, participate in, and/or use safely and with dignity by a person with a disability." (odr.dc.gov)

Distribution

Prior to distribution, both departments reviewed the survey and provided feedback on its relevance to each organization and their ability to distribute. Thereafter, distribution methods differed among both organizations. The survey was sent to senior management at LAPL for review and distribution to cooling center site staff. The survey was distributed internally by LAPL to library branches. In contrast, RAP collected information from each augmented cooling center site and filled out the surveys for the 16 designated recreation centers. As cooling center activations within RAP vary based on location, internal data collection was preferred by RAP in order to complete the surveys.[31]

Although the survey methodology remains consistent among both LAPL and RAP, due to the nature of each organization's distribution process, they are discussed and analyzed separately to bring focus to variations in each organization's results. Survey responses were received between April 17-April 28, 2023.

31 Recreation and Parks Emergency Management, personal communication, May 05, 2023.

Survey Analysis

We conducted our survey analysis primarily through qualitative coding and quantitative inventories. Our coding method combines inductive and deductive categorization, as we began with predetermined categories based on our aforementioned research questions and guiding themes. We also employed an inductive approach through the process of categorizing our data from the survey in order to account for the possibility for new trends or themes to appear that were not initially set. After categorizing questions based on themes of Programming and Site Services, Physical Site, Cooling Center Usage and Demographics, Accessibility and Outreach and Partnerships, we began to use descriptive analysis to help us highlight important data and findings under several categories.

Qualitative Methods and Data: Individual Staff Interviews

Follow Up Survey Interviews

The last question of the survey allowed interested survey respondents to provide their contact information to be contacted for a follow-up interview on their experiences working at a cooling center during extreme heat events. 15 respondents initially indicated they were interested in interviewing. Our team interviewed with 5 individuals who are senior librarians at LAPL, staff at RAP and in the Emergency Department within RAP. Our methodology for conducting interviews followed the same structure of our guiding research themes. We determined the following six questions as a basis to conduct the semi-structured interviews:

Outreach and Partnerships:

- Can you discuss your outreach methods for cooling centers? Are there any communities that have been difficult to reach? What do you think could help improve outreach?

Physical Site Characteristics:

- Does your site present any unique factors that affect cooling and its visitors?

Accessibility & Demographics:

- What resources do you think would improve cooling center usage, operations and accessibility?

Programming and Site Services:

- Can you describe staffing capacity in relation to extreme heat days?
- What do discussions on procedures for extreme heat days look like for your organization? Do you discuss emergency response/ CPR?
- How often does your site discuss procedures related to extreme heat days?

Cooling Center Usage:

- Is there anything you want to discuss about your site and experience with hot weather days and your site?

In addition to the standard questions above, our team also reviewed individual survey responses and drafted individualized questions to further discuss. Because follow-up interviews were conducted in 30-minute time slots, our team prioritized individualized questions and any clarifying questions raised during the interview. Interviews then continued with the pre-prepared questions listed above within the 30 minute time slot.

Additional Interview with Theo Henderson, We the Unhoused

In an effort to include the lived experiences of Los Angeles' unhoused community in our extreme heat research, our team also conducted a semi-structured, 30-minute interview with Theo Henderson, an LA-based unhoused organizer and founder of the "We the Unhoused" podcast. Accounts of the real-life challenges facing LA's unhoused residents during heat waves provided valuable insight on the limitations and shortcomings of the City's cooling centers to meet unhoused individuals where they are. The interview provided key findings to address the needs of unsheltered Angelenos during extreme heat events, such as the development of a mobile cooling station model that meets unhoused communities where they are located and does not rely on policing or coercion tactics to provide cooling interventions.

Qualitative Methods and Data: Site Visits

Our team also collected qualitative data by conducting site visits at two LAPL branches: Hyde Park Miriam Matthews Branch Library in Southwest Los Angeles and Alma Reaves Woods - Watts Branch Library in Southeast Los Angeles. These two LAPL facilities were provided by CEMO as sites that have been selected for the City of Los Angeles' application for funding from the Strategic Growth Council's

(SGC) Community Resilience Center (CRC) program.[32] In April and May 2023, representatives from our team visited the two library branches to: 1) learn how the sites currently operate as cooling centers and 2) understand what features and services allow them to transition to CRCs. While on-site, we toured the facilities and asked questions related to cooling center operations and other programming and services offered to the local community. We also conducted an inventory of the required and optional CRC criteria outlined by the SGC grant requirements. The expansion of Los Angeles' community resilience center network will especially depend on the inclusion of essential resilience center features, including "shade, cooling, internet and transportation services, emergency supplies, services, and education and programming in buildings that are energized with renewables and backed up with battery energy storage."[33] At both branches, we photographed the facilities, walked around the site's exterior, and were given tours by Senior Librarians Justin Sugiyama (Miriam Matthews) and Jasmine Slaughter (Alma Reaves Woods).

Table 4: Features outlined in the Strategic Growth Council's final guidelines for the Community Resilience Center program (as of April 2023)

SGC Community Resilience Center (CRC) Features	
Required	**Optional**
• ADA compliant facilities • Gender-neutral restrooms • Heating, ventilation, and air conditioning (HVAC) system • Air filtration system (MERV 13 at minimum) • Backup broadband access • Backup power generation and/or battery storage • Device charging capabilities for cell phones, personal communications devices, medical devices, power wheelchairs, other assistive devices and technology • Drinking water stored on-site with a plan for re-supply	• Child-care spaces • Computer labs • Conference rooms, community activity rooms, classrooms, group gathering spaces • Medical facilities/resources (medical, behavioral, dental) • Outdoor spaces for community programming, food production, nature-based solutions (ex. groundwater recapture)

32 The SGC announced final guidelines on April 26, 2023. The Notice of Funding Availability (NOFA) and applications are due to be released late Spring 2023. The first awards are to be distributed in Fall 2023.

33 Carpenter, S. (2023, January 12). LA is building resilience hubs as safe spaces for extreme weather events. https://spectrumnews1.com/ca/la-west/public-safety/2023/01/12/la-is-building-resilience-hubs-as-safe-spaces-for-extreme-weather-events

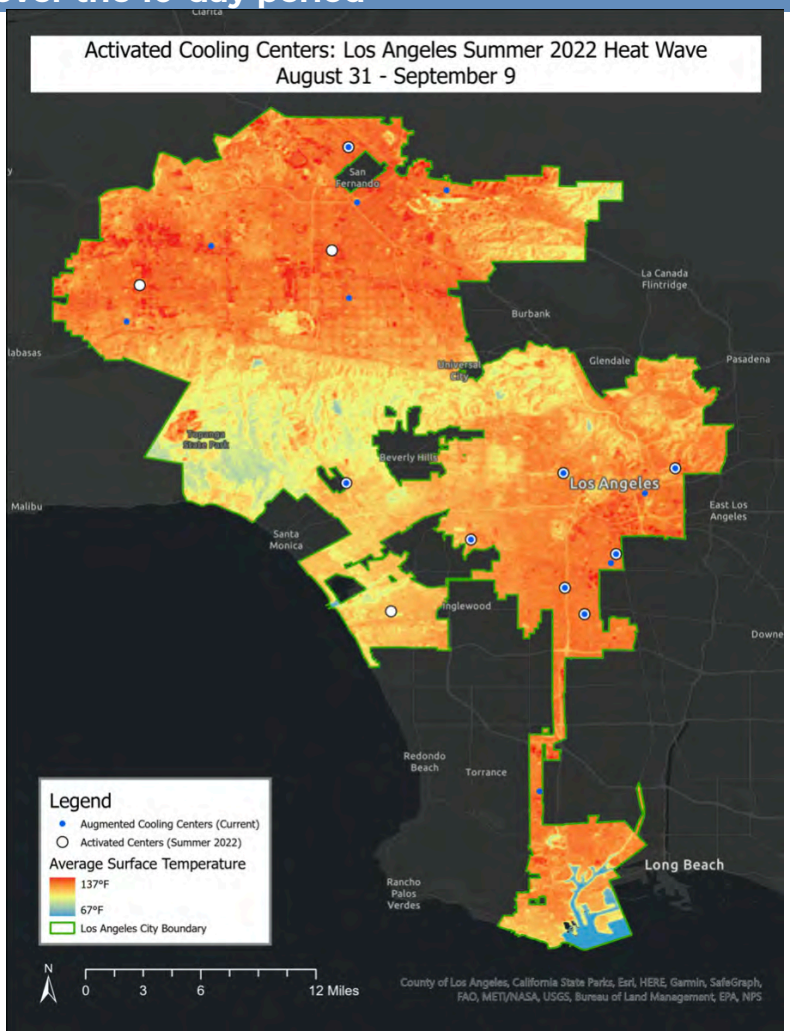
RESULTS & FINDINGS

Existing Center Conditions, Capabilities, and Readiness Analysis

Cooling Center Usage and Capacity

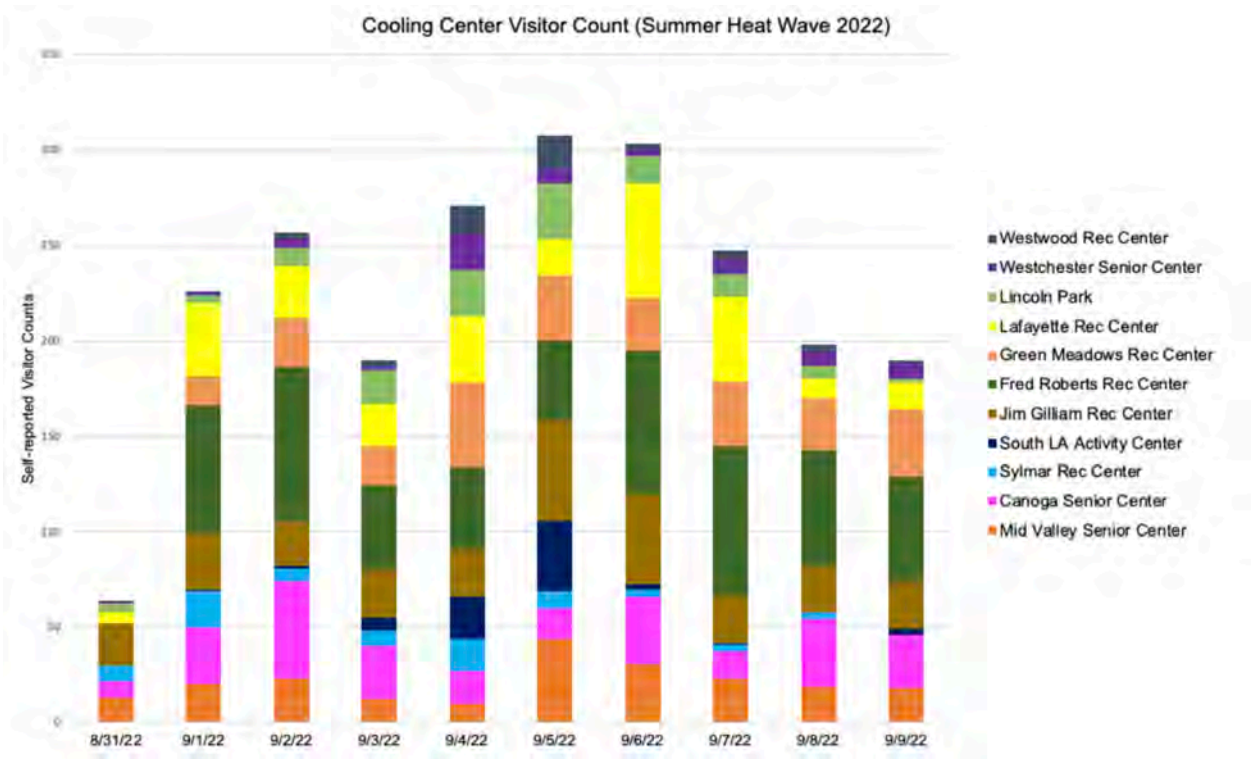
During the late summer 2022 heat wave, CEMO and the Emergency Management Department activated 11 augmented cooling centers across the city over a ten-day period. The map below shows the average surface temperatures during that period, which rose as high as approximately 137°F in areas of darkest orange. The activated centers and CEMO's current roster of augmented cooling center sites are symbolized by white and blue dots, respectively.

Figure 7: Map of augmented cooling center locations, centers activated during the late Summer 2022 Heat Wave, and average surface temperature over the 10-day period



Visitor counts at each activated augmented cooling center are also visualized below. The data are not wholly representative due to self-reported visitor counts that relied on a verbalized reason for their visit, resulting in the likely undercount of visitors who did not interact with staff and were thus uncounted. However, available data does indicate increased visitorship on the second (Thursday, September 1), third (Friday, September 2), seventh (Tuesday, September 6), eighth (Wednesday, September 7), and ninth days (Thursday, September 8) of the 10-day heat wave. Interestingly, overall weekend visitation was low in comparison to visitor counts during the week. Out of CEMO's four regions, centers in the Pacific/South had the highest visitor counts and the highest number of centers activated at four (South Los Angeles Activity Center, Jim Gilliam Recreation Center, Fred Roberts Recreation Center, and Green Meadows Recreation Center). Centers in the West had the lowest visitor counts and only two activated centers (Westchester Senior Center and Westwood Recreation Center). CEMO's Central Regional also had two activated centers (Lafayette Recreation Center and Lincoln Park Recreation Center). The Valley Region had three (Mid Valley Senior Center, Canoga Senior Center, and Sylmar Recreation Center).

Figure 8: Self-reported cooling center visitor counts at activated facilities during 10-day Summer 2022 heat wave



LAPL provided maximum capacity figures for meeting rooms at all of their sites except two - the Malabar and Felipe de Neve branches (see Appendix E). Although RAP was able to provide maximum capacity for their recreation centers, they noted that any concurrent programming or events would lessen the capacity for exclusive cooling center functions on extreme heat days. Conference rooms, community activity rooms, classrooms, and group gathering spaces are listed as optional criteria in the SGC's list of community resilience center features, but are considered facility elements that can encourage social cohesion, service delivery, and disaster preparedness.[34] These dedicated spaces are identified in the CRC program guidelines as places where information can be shared and displayed with local residents. In addition, group gathering spaces could potentially act as designated rooms for cooling purposes - providing seating, bottled water, and other heat specific resources. Identifying facilities with greater gathering space capacities in areas with high vulnerability could be beneficial for future community resilience centers.

The South Los Angeles Sports Activity Center, Mid Valley Senior Center, and Lafayette Recreation Center, all RAP sites, are the only facilities for which summer 2022 heat wave and maximum capacity data are both available. On their busiest days during that period (days with the highest number of visitors), South Los Angeles Sports Activity Center reached 97% occupancy, Mid Valley Senior Center reached 79%, and Lafayette Recreation Center reached 15%.

While important, these results are not a fully accurate representation due to the likelihood of undercounting in the data collection process. In fact, it is likely that occupancy rates were higher. In addition, the RAP data reflects overall site capacity, not designated gathering space capacity.

Staff Survey

LAPL Staff Survey Results

The Los Angeles Public Library is a network of 72 branches located across the city of Los Angeles. The cooling centers staff survey received 64 responses from 39 distinct branches, a 54% response rate.

34 Community Resilience Centers (CRC) Program: Round 1 Final Program Guidelines. (2023). California Strategic Growth Council. https://sgc.ca.gov/meetings/council/2023/04-26/docs/20230426-Item5a_Attachment_A_CRC_Guidelines.pdf

Staff positions represented in the initial survey sample included:

- Senior Librarian/ Branch Manager: 29
- Librarians: 15
- Library Assistants: 1
- Clerks: 19

Taking the duplicates into consideration, we narrowed down responses to reflect one response per site.[35] After adjusting the data, the following are the staff positions and counts reflected in our analysis:

- Senior Librarian/ Branch Manager: 28
- Librarians: 6
- Clerks: 5

Below, we provide a summary of highlights found from each of our five guiding themes:

Programming and Site Services

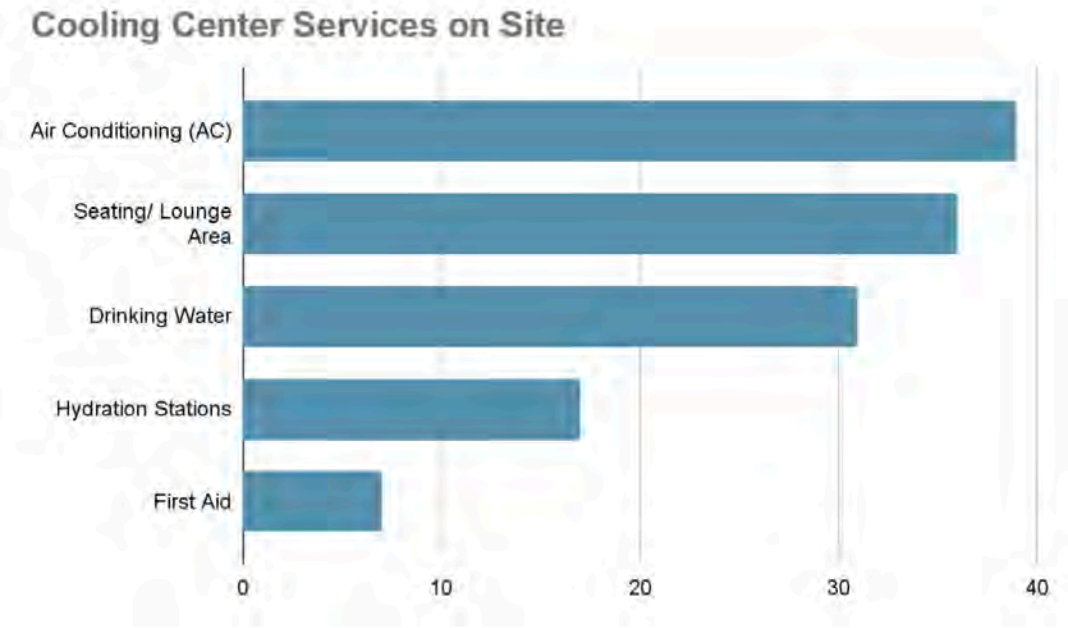
Site services indicated by respondents are visualized below in **Figure 9**. Air conditioning was the most offered service related to cooling, provided at all 39 sites. With only seven sites responding affirmatively, first aid was the least offered service. Although LAPL confirmed that first aid is not a requirement, some sites have indicated that first aid is offered, which opens up an opportunity to enhance first aid offerings and expand partnerships with emergency response organizations to support staff and visitors. Based on the data, there is also an opportunity for drinking water and hydration stations to be offered at more sites.

Leadership from LAPL indicated that discussions related to extreme heat procedures are not often discussed, and therefore are not measurable, by branch. Incorporating increased discussion and preparedness may be beneficial to support staff during extreme heat days. When asked if it would be helpful to have more staff during extreme heat days, staff at 23 sites (59%) indicated that more staff during extreme heat days would not be helpful. Fourteen sites indicated that more staff would

35 Although we received 64 responses in total, many of them were duplicates (or multiple responses from the same branch). While respondents held different staff positions and with valuable perspectives and insights, our analysis was designed to analyze only one survey response per site. As a result, we only included the first response received in order to remain consistent in our data. Full datasets can be found in Appendix B.

be helpful, particularly for purposes of security. Although widespread information alludes to resource constraints during extreme weather events, LAPL staff responses indicate that individual locations may not require additional staff, and to incorporate such without consulting LAPL branch staff may do more harm than good. Additional discussions and consultations with staff are required to understand LAPL staffing capacity and potential needs during cooling center activations.

Figure 9: LAPL Cooling Center Site Services

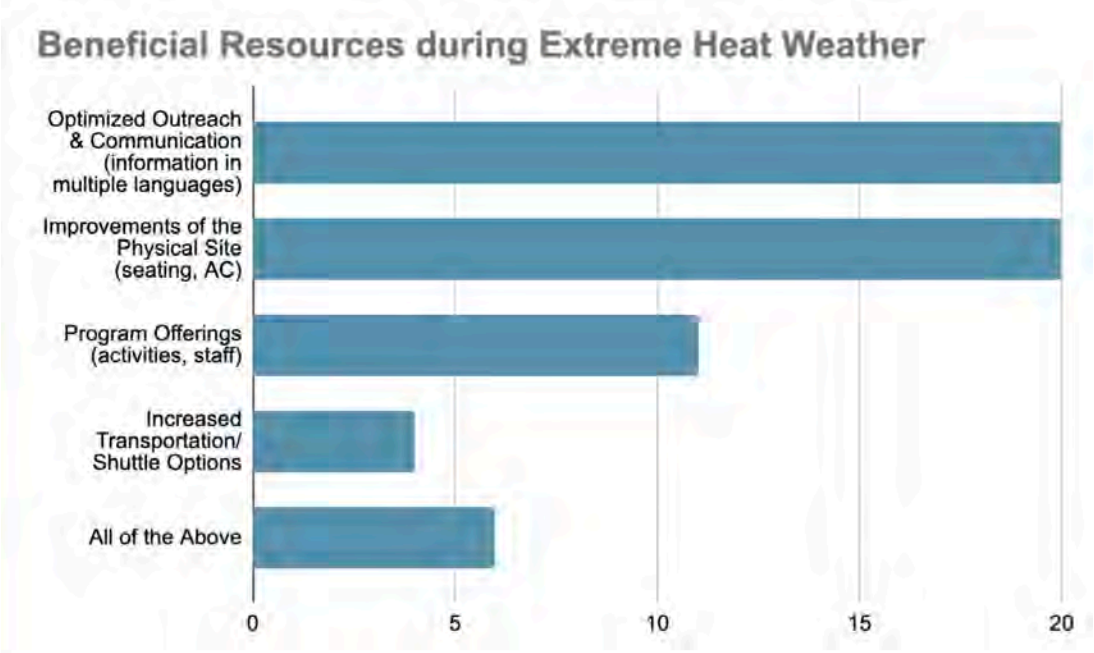


Physical Site

When asked about the physical site, particularly about AC reliability and functionality, 18 sites (46.2%) stated that the AC works great and feels cool during regular and hot days. On the other hand, 13 (33.3%) sites indicated that the AC works well during regular days, but does not function well during hot days. A few sites indicated that although AC works great during both types of days, the AC is unreliable and has failures. This pattern of unreliability is one that should be further investigated. This includes examining all HVAC systems, their functionality, year built, how often they are serviced and response time for servicing failures, especially during extreme weather conditions.

Figure 10 visualizes additional resources that would be beneficial for sites during extreme heat, with improvements in outreach, communication and the physical site as the most indicated resources that would be helpful. Comments about security on site, mental health and resources for unsheltered folks were also noted as beneficial in the

Figure 10: LAPL cooling center site resources that would be beneficial during extreme heat weather



Cooling Center Usage and Demographics

Survey responses regarding the frequency of cooling center usage showed that 25 sites (64%) see people visit more often on hot days. Twenty-five respondents also reported that they notice an increase in overall visitation, noticing more visitors at the site during hot days. Twenty-six sites (66.7%) reported that visitor activities do not change during hot days, suggesting that regular programming and site uses continue during cooling center activations.[36]

Overall, staff noticed an increase in both elderly and unhoused visitors on hot days, suggesting that these two population groups utilize LAPL cooling centers at a higher rate than other population groups. As a result, programs and resources at cooling centers must especially consider the needs of elderly and unsheltered communities. Ten sites indicated that they did not notice a change in demographics as compared to a regular day.

36 12 respondents (30.8%) indicated that during hot days, visitor activities changed. For those respondents who reported a change in user activities, For respondents that indicated that usage activities change: 5 respondents stated that visitors use the site more casually, 4 respondents stated that visitors use the internet or charge their devices more, 3 respondents stated that visitors spend more time at the branch. 2 respondents stated that visitors' emotions shift negatively.

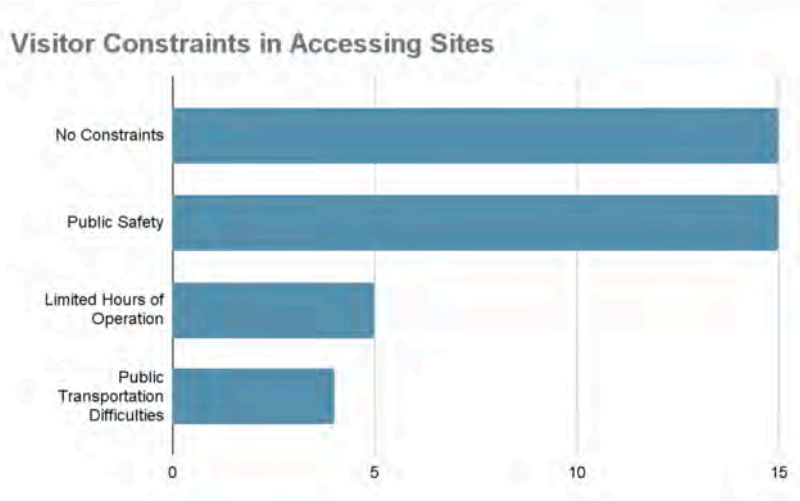
Accessibility

Senior leadership at LAPL stated that all sites must comply with the Americans with Disabilities Act (ADA). Although we did not receive specific details about each site, regular inspection and maintenance is needed to confirm ongoing ADA compliance. LAPL indicated that standard procedures do not call for LAPL staff to be trained in first response. Procedures in place rely on outside emergency response for assistance. Moreover, LAPL stated that sites allow service animals only at all times.

Staff survey data on language accessibility revealed English and Spanish as the most common languages spoken by visitors and supported by staff (indicated by 25 sites). Farsi, Mandarin, Korean, Tagalog, Russian, Japanese, and Vietnamese were also listed as languages spoken by visitors, but not supported by staff. Language needs vary from branch-to-branch, and successfully providing multilingual services relies on consultation with individual library branches to determine the linguistic needs of the surrounding community.

When asked about extending cooling center hours, only six sites (15.4%) stated that operating hour extensions would be beneficial. More research on hour extensions during extreme heat is needed, as the benefits of extended hours of operation may vary based on the location, size and usage of individual sites. **Figure 11** depicts visitor constraints as described by staff, with 15 sites reporting there are no constraints for visitors in accessing their site. However, 15 other sites indicate public safety as a dominant concern. Public safety and lack of security were also identified under themes of 'Site Services' and 'Physical Site.'

Figure 11: LAPL visitor constraints in accessing cooling center sites



Outreach and Partnerships

Data on outreach methods revealed that social media was used by 28 sites (72%), followed by physical advertising (12 sites). Responses also highlighted word-of-mouth as another outreach method, and multiple sites indicated that outreach is not conducted at a branch level, but rather conducted by the City or LAPL at large. Because unsheltered and elderly individuals appear to be prominent users of cooling centers, social media may not be the most effective outreach method in place due to varying access to technology. Word-of-mouth and physical advertising may help expand outreach, such as placing banners on the building or other signage visible at the street level.

Sixteen sites stated that outreach does not target particular demographics. Based on the diversity of languages spoken by visitors, outreach can also be improved via multilingual communications strategies. Other responses indicated that outreach methods targeted local communities near the branch, including seniors and unsheltered residents. Neighborhood councils, schools, and mental health departments surfaced as prominent outreach partners with LAPL cooling sites.

#	Key Survey Findings
1	LAPL cooling centers are used by elderly and unhoused individuals at a higher rate than other population groups
2	RAP sites observed an increase in visitors during extreme heat days
3	LAPL indicated that discussions related to extreme heat procedures are not often discussed by branches
4	The most used outreach method among LAPL and RAP sites was social media
5	AC was the most offered service related to cooling offered at LAPL and RAP sites

Follow Up Survey Interviews

LAPL - Summary of Interviews

Three follow-up interviews with library staff confirmed and expanded on trends noted from survey results, particularly on HVAC reliability issues and extreme heat communication, procedures and outreach (see **Appendix D** for detailed results). HVAC unreliability, primarily among older HVAC systems, was noted as an issue during staff interviews. Also, communication between branches and visitors was not consistent. Interviewees described unclear outreach responsibilities between individual branches,

LAPL, or the City. The interviews also highlighted interest among staff in expanding cooling center resources toward a community resilience hub model, a key insight not found in the survey responses (particularly when asked about emergency response and additional resources that would be beneficial). The disproportionate heat risk facing certain communities, such as unhoused residents, was also highlighted by interviewees. Based on these results, efforts to improve and expand emergency procedures, programs, resources, communication strategies, and partnerships can bolster cooling center operations in communities with high cooling center dependency.

RAP - Summary of Interviews

Results from two interviews with RAP staff provided additional insights that were not seen with survey results. One interviewee provided more in-depth information on RAP's cooling center activation process and its implications for planning and operations. In contrast to LAPL, which operates all branches as cooling centers during a heat wave, RAP will select which augmented cooling centers to activate when an extreme heat event is forecast. Recreation center staff may be sent to a different location during cooling center activation periods in order to accommodate increased visitors at high-use sites. Moreover, RAP reserves the ability to shut down cooling center operations if a site is underutilized in order to shift operations to a recreation center with more demand. Daily programming also affects cooling center activations and can result in challenges accommodating various types of visitors (e.g., youth program participants, cooling center users, etc.) and optimizing multi-use facilities during heat waves. Interviewees also indicated that RAP's Public Relations Officer supports clear and consistent public outreach on behalf of the cooling center sites. One major finding included the holistic benefits of community resilience hub features at Green Meadows Recreation Center, such as solar panels, shade structures, backup energy, and computers/WiFi access.

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Theo Henderson, We the Unhoused

In consideration of the acute challenges facing unhoused community members during extreme heat events, our team also reached out to Theo Henderson, local unhoused rights activist with We the Unhoused, to conduct an interview and learn more about the lived experiences of unhoused Angelenos in relation to extreme heat exposure. Theo reaffirmed that unhoused residents are placed in particularly vulnerable situations during heat waves. However, Theo cautioned that "solutions don't come with aggression and policing," expressing strong disapproval of the City of Los Angeles' general treatment of unhoused Angelenos and hostility and harassment experienced by unhoused people at City-run cooling centers. In particular, Theo cited LAPL's restriction against bringing personal belongings inside library branches that can become a wholesale prohibition for many unhoused people to access a cooling center. However, even if unhoused individuals are able to enter a cooling center location, their presence is frequently criminalized, citing instances of individuals having the police called on them and being forcefully removed for simply falling asleep on the premises. Theo reiterated that "during climate change, we cannot have punitive solutions," and called for "outside the box" approaches that can meaningfully engage and respect unhoused communities without pushing individuals into shelter and seizing their possessions in the process. Given the experiences of unhoused residents during visits to public libraries and other cooling centers, Theo reaffirmed that traditional cooling center locations are unwelcoming and insufficient to meet the needs of unhoused people.

Theo advised that mobile cooling centers that could bring services directly to unhoused communities would be much preferred over other solutions. Such mobile cooling stations can be set up in locations where unhoused communities already exist, and provide heat-related services and amenities such as shade, seating, cold water, fans, misters, WiFi hotspots, and on-site medical treatment. By "creating a place for them to have

37 Recreation and Parks Cooling Site, personal communication, May 23, 2023.

their own system," Theo's proposed model would allow unhoused people to utilize cooling stations for immediate heat relief, without policing or coercion into programming that is not desired. The City's role in this effort would be to provide funding and resources for mutual aid groups with strong community connections to operate the mobile cooling stations without sweeps or criminalization.

Regarding existing City-run cooling centers at libraries and recreation centers, Theo supports an expansion of grab-and-go items such as cold water (no warm or hot water) and battery-powered fans and spray bottles, as well as accessible charging stations, spaces to store personal possessions, and mobile laundry facilities to limit the chances of throwing away belongings. Theo also stated support for community building efforts with unhoused residents, including educating City staff on "human dignity and common sense" to increase their understanding of the unhoused community's unique experiences and challenges faced when attempting to access cooling center facilities.

Site Visits

Following the staff survey and additional interviews, our team conducted site visits to document existing operations and services at two cooling centers that are being considered for community resilience center investments. As of publication, the two LAPL library sites (Hyde Park - Miriam Matthews Branch and Alma Reaves Woods - Watts Branch) will be included as part of the City of Los Angeles' grant application to the State of California's Strategic Growth Council Community Resilience Centers program. During the site visits we met with staff, toured the facilities, and utilized the CRC grant program criteria to assess how closely their current operations compare to a community resilience center. We utilized the below criteria to understand what resiliency features the facilities are currently equipped with, as well as what may need to be added to offer more robust resources as a future community resilience center.

SGC Grant Applicants' Adherence to SGC Criteria

The Strategic Growth Council (SGC) adopted the Community Resilience Centers Program's Round 1 Final Guidelines during the April 2023 Council Meeting. The SGC criteria for CRCs helps determine a site's progress towards becoming a community resilience center **(Table 5)** based on a variety of factors that convey community preparedness and resiliency for climate emergencies and other crises.

Based on our site visits, we hypothesize that Hyde Park - Miriam Matthews Branch and Alma Reaves Woods - Watts Branch are equally or more prepared than other library branches to become community resilience centers. The sites are currently equipped to offer a number of resiliency amenities to the public (e.g., air filtration, charging stations, outdoor spaces), while key features such as backup energy, water, and broadband are not offered at either site. Other features such as refrigeration and kitchen spaces are present on-site but only available to staff. If converted into community resilience centers, adjustments could be made to install backup energy and water sources, and also allow visitors to make use of existing refrigerators and kitchenettes during emergencies.

Given that each site serves primarily as a public library, there is limited space available to make further additions to the building. Providing overnight shelter accommodations could prove challenging, as the sites lack storage space for cots and blankets. However, because the sites also provide robust community programs and resources all under one roof, they are likely well-positioned to serve as trusted neighborhood institutions during emergency and non-emergency periods. In particular, Hyde Park - Miriam Matthews Branch is LEED certified, equipped with solar panels and slated to receive EV charging stations in the coming months – demonstrating how a library branch can be upgraded for community resiliency, sustainable infrastructure and renewable energy.

Table 5: The Strategic Growth Council's Community Resilience Centers grant criteria helps determine a site's progress towards becoming a community resilience center based on a variety of factors that convey community preparedness and resiliency

	Miriam Matthews	Alma Reaves Woods	Notes
	Required		
ADA compliant facilities	X	X	
Gender neutral restrooms			Need to confirm with site
Heating, ventilation, HVAC system	X	X	
Air filtration system	X	X	MERV-13 air filtration system installed in past 2 years (MM)

Backup broadband access			
Backup power generation and/or battery storage			Existing generators do not power entire building (MM); Backup power only extends to lights (ARW)
Device recharging capabilities	X	X	Small charging kiosk (MM); Many outlets available (ARW)
Drinking water stored on-site, re-supply plan			
		Optional	
Child-care spaces	X	X	Changing station in bathroom (MM); designated children's area (ARW)
Computer labs	X	X	
Group gathering space	X	X	
Medical facilities and resources			
Outdoor spaces	X	X	

Site Visit #1: Hyde Park Miriam Matthews Branch Library (April 28, 2023)

Site Description

On Friday, April 28th, two team members conducted a site visit at the Los Angeles Public Library (LAPL) Hyde Park Miriam Matthews Branch Library located at 2205 W. Florence Avenue in Hyde Park within the South region of Los Angeles. This branch was constructed in 2006 and named after the first African American librarian in California whose 33-year tenure in the Los Angeles Library system from 1927–1960 was dedicated to the preservation of black history.[38]

With the exception of staff offices and a meeting space, this small branch library consists of one open space for adults and children. The building received an LEED Silver rating for sustainability and it improved upon its service most notably through

38 https://bdt.degruyter.com/entry/bdt_17_035/

increases in volumes from 25,000 to 40,000 and a tripling of computer stations. The goal was to provide a library that "is in complete response to the people who occupy it," as architect Craig Hodgetts stated. In the first year after completion, statistics showed that patronage and book circulation tripled from previous use.

Source: photo taken on 4/28/2023 by research team

Existing Conditions & Amentities

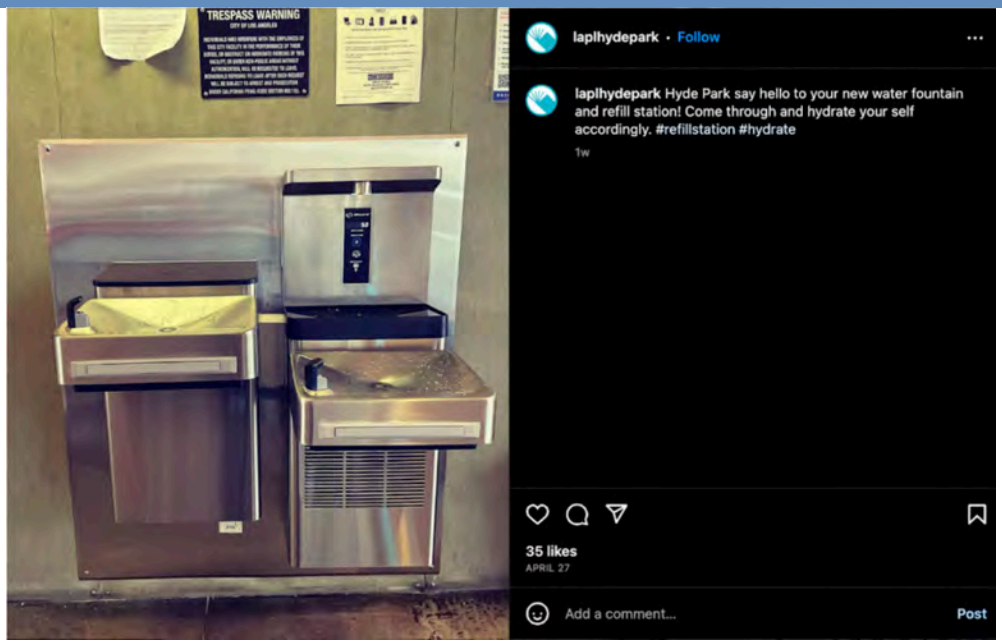
- Parking Lot
- Bike Rack Available
- Book Bundles To Go
- Cybernauts
- Friends Group
- Hotspots
- iPad Minis
- Language Collection: Spanish
- Laptops (in-building use)
- Public Computers
- Scanner
- Student Zone
- Tech2Go Bundles
- Teen Quad
- Urban Garden
- Wi-Fi
- Wireless Printing
- ZoomText

Community Resilience Centers (CRC) Analysis

In terms of community resilience center amenities available at Hyde Park Miriam Matthews (MM) Branch Library, the entire site is considered ADA accessible and operates a new HVAC system with air filtration installed approximately 2 years ago. The building is LEED certified featuring roof solar panels installed in 2004. The branch intends to use 3-4 of the existing 20 parking spots to create EV charging spots. The branch has a newly installed hydration station as of April 2023 and maintains a refrigerator and a reservation-only meeting room for public programming and

events, although access is restricted to the public. There is also a small kitchen on site, which is limited to staff-use only. The site provides an electronic device charging and borrowing station and houses a computer lab with ~25 public computer stations and youth academic programming. In the event of a power outage, MM is equipped with an emergency power system but does not have backup power, water, or broadband service. There are currently no designated sleeping quarters for use. Per LAPL regulations, only service animals that are trained to perform a task are allowed on-site, but these rules may be relaxed during extreme heat events. The site has an outdoor community garden space accessible only during community or staff programming and events.

In April 2023, the site received a new hydration station for library users. Source: Hyde Park Miriam Matthews Branch Library Instagram Account



As it currently operates, MM would require substantial infrastructure investments to convert it into a community resilience center that meets the guidelines of the Strategic Growth Council's grant program, including a larger kitchen and child care areas, backup power/water/broadband, and shower installation. The site lacks these amenities that would allow it to more holistically care for its visitors in the form of meal preparation, medicine storage/care, personal hygiene, and more. Notably, LAPL may also begin to onboard social workers at its branches which will further aid existing library staff when increased visitors (many of them unhoused) visit the site during extreme heat events. Given the site's extensive community program offerings (especially for youth), popularity with the community, and location in a historically

underserved community, MM could feasibly transition into a community resilience center that is designed to meet the needs of local residents in the case of a heat wave or other crisis event.

Site Photos

From Left to Right: 1) The site has an extensive youth and young adult section with reading materials, community programming, and technology & art resources; 2) The site has a locked and enclosed community garden that is open on special occasions. Library visitors must have staff approval to access the garden; 3) The site has an electronic device charging station and community electronics borrowing program; Source: photos taken on 4/28/2023 by research team

Site Visit #2: Alma Reaves Woods - Watts Branch Library (May 6, 2023)

Source: photo taken on 5/6/2023 by research team

Site Description

Located at 10205 Compton Ave in the Watts neighborhood of Los Angeles, LAPL's Alma Reaves Woods Branch (ARW) opened at its current site in 1996, and currently operates robust community programs for children, adults, and families. As of the date of our visit, eleven staff members work at ARW, which also operates as a "music branch" due to its ongoing partnership with the Watts Willowbrook Conservatory to provide on-site music lessons to youth. While not mandatory, the site aims to offer at least one community event per week, typically hosted in the Community Room (60-person occupancy limit) and a small, enclosed outdoor patio space. Staff members regularly conduct program outreach via social media, but have not advertised cooling center operations in the past. Plans are currently underway to remodel the site for updates to the circulation and information desks, as well as convert the old bookstore room into a music recording studio. Two members of the research team visited the site on May 6th, 2023.

Existing Conditions & Amenities

Like all other LAPL branches, ARW serves as a cooling center during extreme heat events. During hot days, visitors are welcome to use the entire library and make use of the site's seating areas, air conditioning, reading materials, broadband internet, charging outlets, drinking water, and restroom facilities. While LAPL will send extra drinking water to the facility on hot days, there is no backup water storage or reservoir

on site. The branch will see residents of all backgrounds come in during high-heat days, with noted increases in unhoused individuals, unemployed people, LGBTQ+ visitors from a nearby community center, and children and youth who come over from nearby Ted Watkins Park. According to staff, while most visitors do not stay at the library for long durations, unhoused people were most likely to remain on site for most of the day. Overall, there has been a slowdown in the number of visitors to the branch since the COVID-19 pandemic, and staff noted a general lack of awareness in the local community that the library branch exists and is open to the public (regardless of cooling center operations).

ARW adheres to all visitor rules and regulations established by LAPL, with some flexibility to relax enforcement during inclement weather events. For example, the site operates under a large bag restriction and prohibits blankets from being brought inside. Visitors must find other accommodations for such items before they are allowed entry, as there is no dedicated storage area provided for personal belongings. Someone without shoes or adequate clothing will also be denied entry. Moreover, visitors are not allowed to sleep inside the library.

As a result, unhoused individuals are most likely to face significant barriers to entry when attempting to access library sites during a heat wave (or any other time of year). Despite these restrictions on entry, ARW staff continues to offer drinking water to all (either from the water fountain or bottled water) during cooling center activations, and acknowledge the need for more hot weather supplies to be provided to unhoused individuals who show up to the site, such as handheld fans, spray bottles, hats and/or visors. Staff also note that providing disposable shoes and/or flip-flops can help remove a key barrier to entry (i.e., no shoes, no service).

Additionally, South LA's Homeless Outreach Program Integrated Care Services (HOPICS) regularly works with ARW to offer food, medical services, temporary housing, and shower access to unhoused visitors, and the LAPL system is currently developing its own social worker program to provide social services for unhoused individuals at branch locations.

Community Resilience Centers (CRC) Analysis

In terms of community resilience center amenities available at the Alma Reaves Woods - Watts Branch, the entire site is considered ADA accessible and operates an HVAC system with air filtration. The branch has a touch-free water bottle filling station and maintains a refrigerator for public programming and events, although access is restricted to the public. There is also a small kitchen on site, which is limited to staff-use only. The site provides outlets for charging on tables, houses a computer lab with ten public computer stations, and offers laptops for check-out. In the event of a power outage, ARW is equipped with emergency lights but does not have backup power, solar panels, or backup broadband service. There are currently no designated sleeping quarters and no extra storage space to place cots when not in use. In terms of child care, the children's reading space could be converted to a child care area if needed. Per LAPL regulations, only service animals that are trained to perform a task are allowed on-site, therefore no accommodations are made for pets or emotional support animals. The site also includes a community/conference room that connects to an outdoor patio space typically used for programs and events.

As it currently operates, ARW would require substantial investments and renovations to convert it into a community resilience center that meets the guidelines of the Strategic Growth Council's grant program. However, given the site's extensive community program offerings and location in a historically underserved community, ARW could feasibly evolve into a community resilience center that is designed to meet the needs of local residents in the case of a heat wave or other crisis event.

Site Photos

Clockwise from Top Left: 1) Children's reading room; 2) Outdoor patio space used for community programs and events; 3) Interior of Alma Reaves Woods - Watts Branch Library; 4) Community room and entrance to outdoor patio used for community programs and music lessons; Source: photos taken on 5/6/2023 by research team

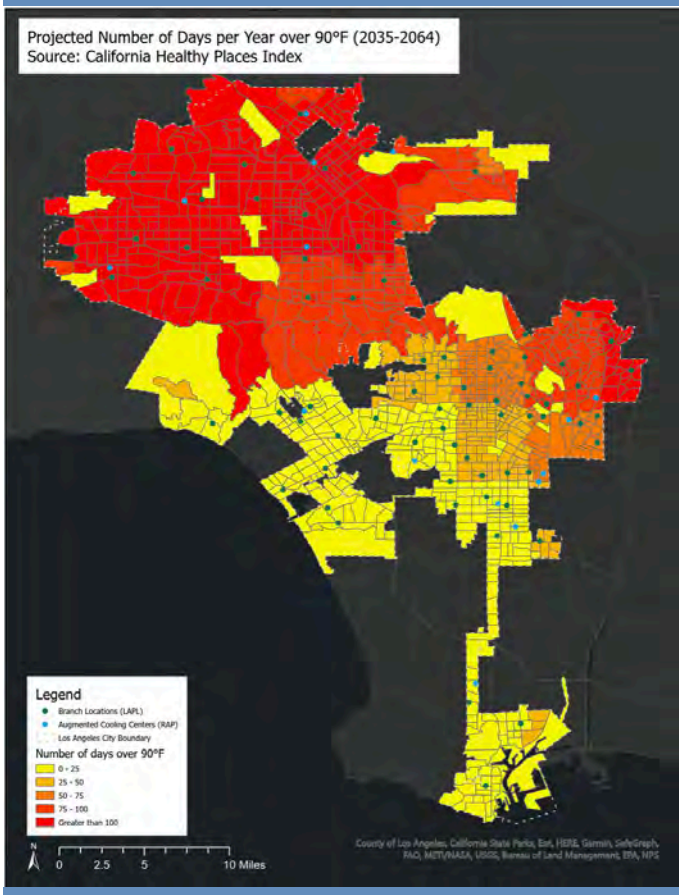
Dark Spots Analysis

Finally, we turn to our quantitative analysis of Dark Spots, areas of the city without sufficient cooling resources. The above results of the Existing Center Conditions, Capabilities, and Readiness Analysis should be considered jointly with the findings of our Dark Spots Analysis, which incorporated future heat projections, social vulnerability indicators, unhoused population data, and building age. These results were informative in identifying areas of Los Angeles that may rely heavily on cooling centers during periods of extreme heat and would benefit from improved access to them. Our Dark Spots Analysis indicates that parts of the North San Fernando Valley, South San Fernando Valley, East Los Angeles, South Los Angeles, and Harbor region have heightened sensitivity and exposure to extreme heat that suggests an increased

need for cooling center access. Furthermore, certain neighborhoods do not currently have access to a public cooling center within a one-mile radius.

A total of 19 criteria were combined to create our Dark Spots Analysis index; however, many of the layers are compelling on their own. The projected number of days over 90°F annually between 2035 and 2064 are heavily concentrated across the San Fernando Valley, East Los Angeles, and neighborhoods in the Santa Monica Mountains not immediately adjacent to the coast. Across the city, residential buildings built prior to 1969 are presumably less insulated and have lower levels of building thermal performance to maintain safe and cool temperatures indoors. These buildings are also less likely to be equipped with air conditioning, given that the prevalence of residential central air conditioning did not come about until the late 1960s. Overall, the city's oldest buildings (built in or before 1939) are largely concentrated in Central, South, and East Los Angeles.[39]

Figure 12: Projected number of days per year over 90°F in the City of Los Angeles (HPI)



Data regarding rent burden indicates that renters across the city are spending upwards of one-third of their monthly income on housing expenses (rent and utilities), and there is not much geographic differentiation in this regard. CVA data indicates a notable concentration of outdoor workers in South Los Angeles. Individuals without health insurance tend to reside in Central and South LA. Households without access to a car

39 Specific neighborhoods include Downtown Los Angeles, Hancock Park, Hyde Park, Mid-Wilshire, Chesterfield Square, Silver Lake, Echo Park, Manchester Square, West Adams, and Gramercy Park. See additional building age maps in the **Appendix.**

are concentrated in Central, East, and South LA. Larger percentages of Black residents are found in South Los Angeles. Latinx populations are more evenly distributed across the city, but concentrated in the Northeast San Fernando Valley, East, Central and South Los Angeles, and parts of the Harbor region. Mobile home residents are primarily found in the northern regions of the San Fernando Valley.

The maximum sensitivity score generated by the GIS Suitability Modeler using our index is approximately 4.4. Using the City of Los Angeles' neighborhood service areas classifications, which have been used previously for reports regarding city services, we ranked areas of the city according to our environmental and human sensitivity indicators **(Figure 13)**. In order of most sensitive to least sensitive, the areas are:

- South Valley (4.4)
- North Valley (4.3)
- East Los Angeles (4.2)
- South Los Angeles (4.1)
- Harbor (3.8)
- Central (3.8)
- West Los Angeles (3.5)

In overlaying LAPL and RAP locations and their quarter, half, three quarter and one mile buffers, we find that cooling center coverage is fairly extensive across Los Angeles, particularly when coverage is defined by a one-mile radius **(Figure 14)**.

However, the lack of cooling center density in the San Fernando Valley should be addressed, especially given the region's propensity for high temperatures and anticipated increase in extreme heat days in the coming years. Specifically, neighborhoods lacking in access to City-owned and operated cooling centers that also tend to be low-to-moderate income include parts of North Hollywood, Sun Valley, Arleta, Mission Hills, Van Nuys, Lake Balboa, Northridge, and Canoga Park. Other highly-vulnerable areas of the city that fall outside the one-mile radius of an existing cooling center include parts of Glassell Park, El Sereno, and Gramercy Park.

The majority of LAPL and augmented cooling center sites are located in areas of the city where more than 80% of the population reside within one half-mile of a major transit stop, excluding a handful of sites in the North Valley, East Los Angeles, and Harbor. Access to major transit stops suggests greater capacity to reach a cooling center location via public transit, although more research is needed to understand the transit accessibility of existing cooling centers in Los Angeles.

Figure 13: Sensitivity levels by neighborhood service area in LA

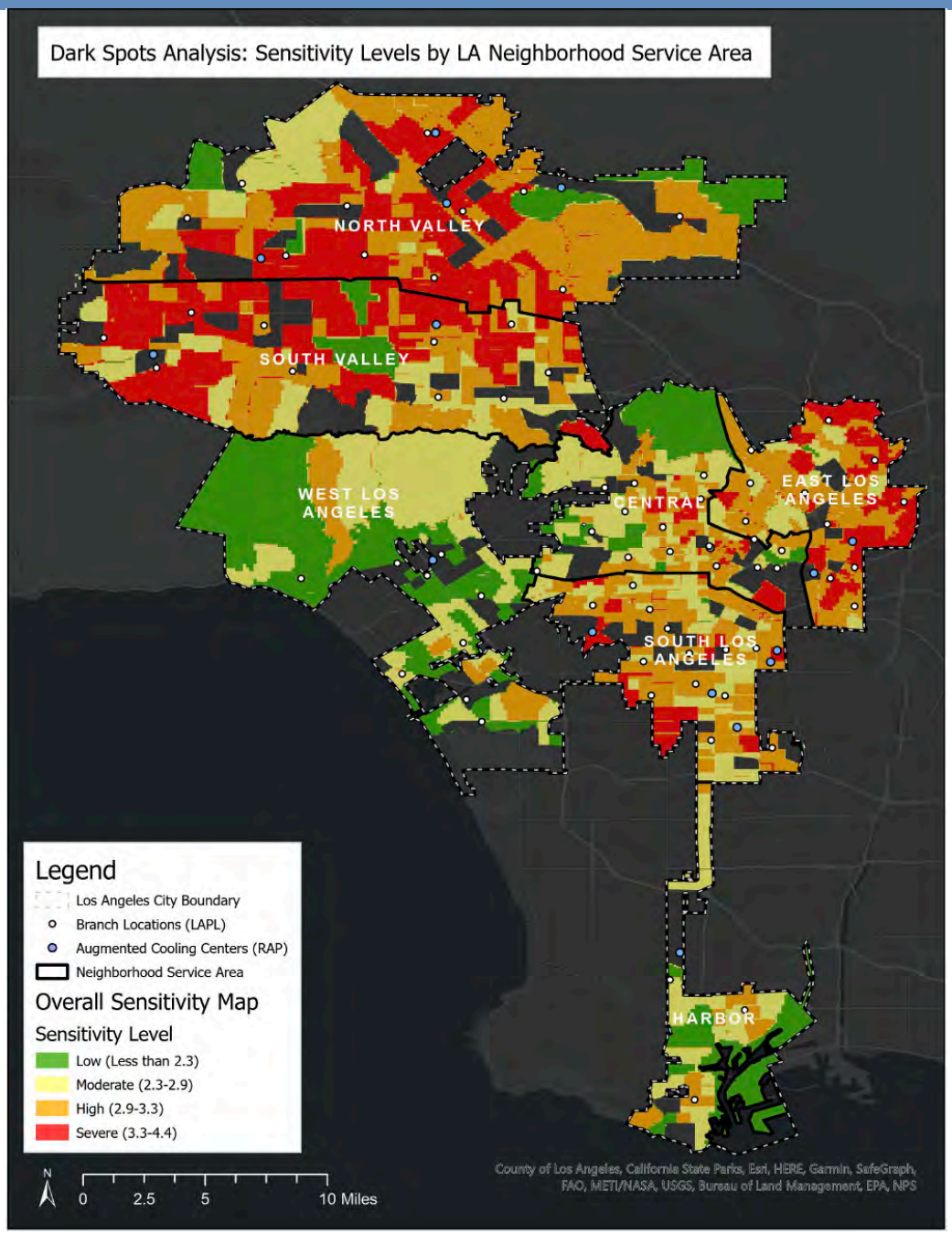


Figure 14: Sensitivity in the North Valley and one mile buffers around LAPL branch locations and RAP augmented cooling centers

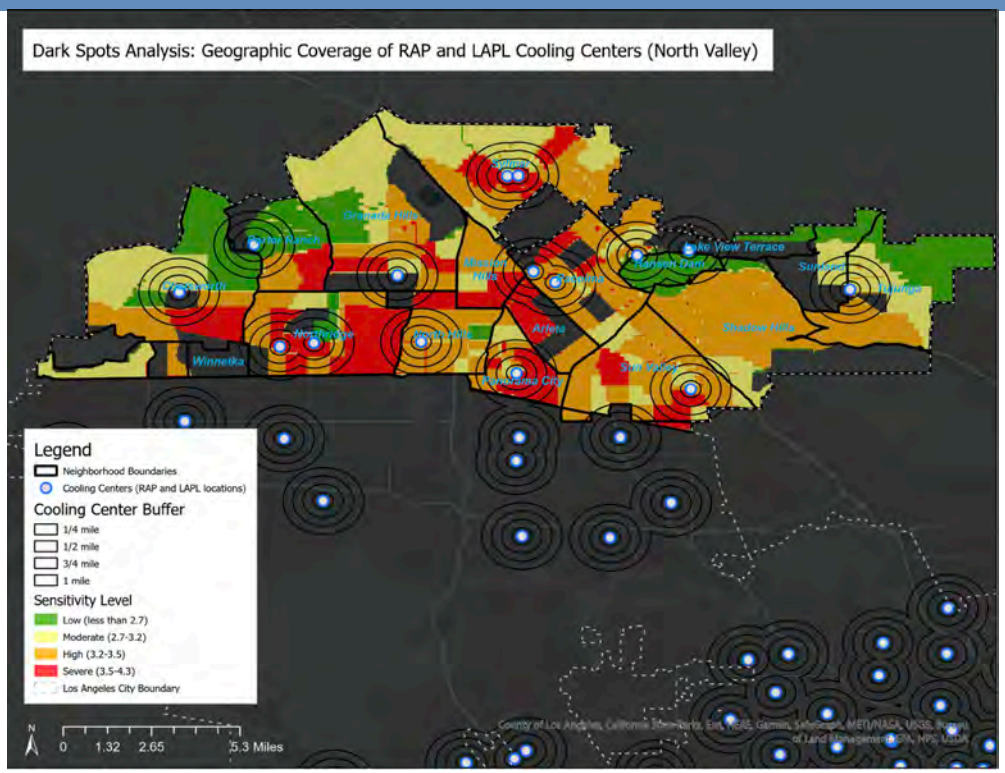
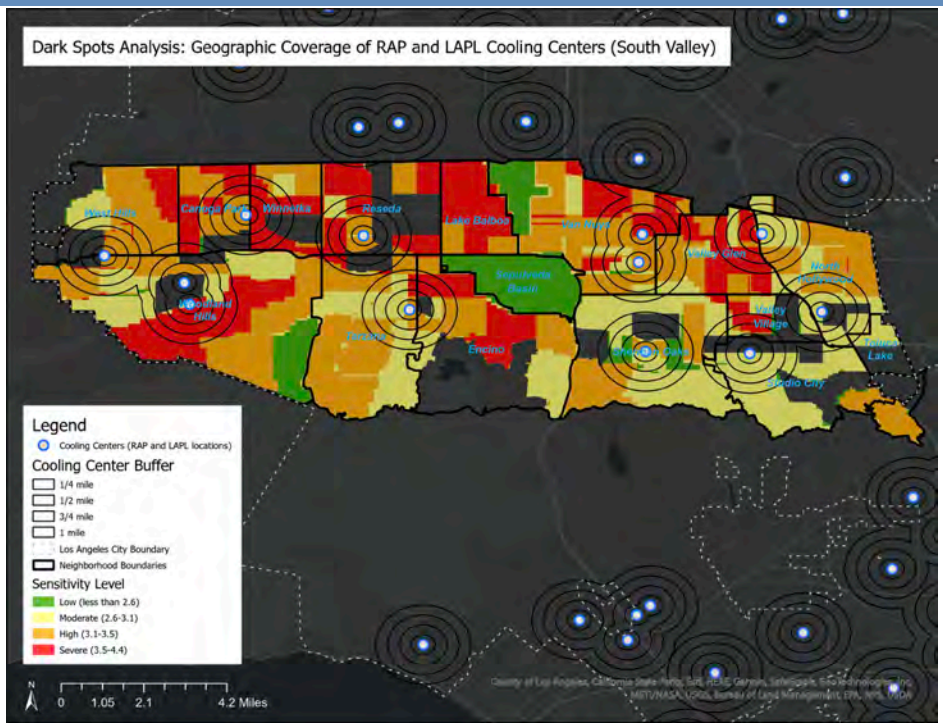
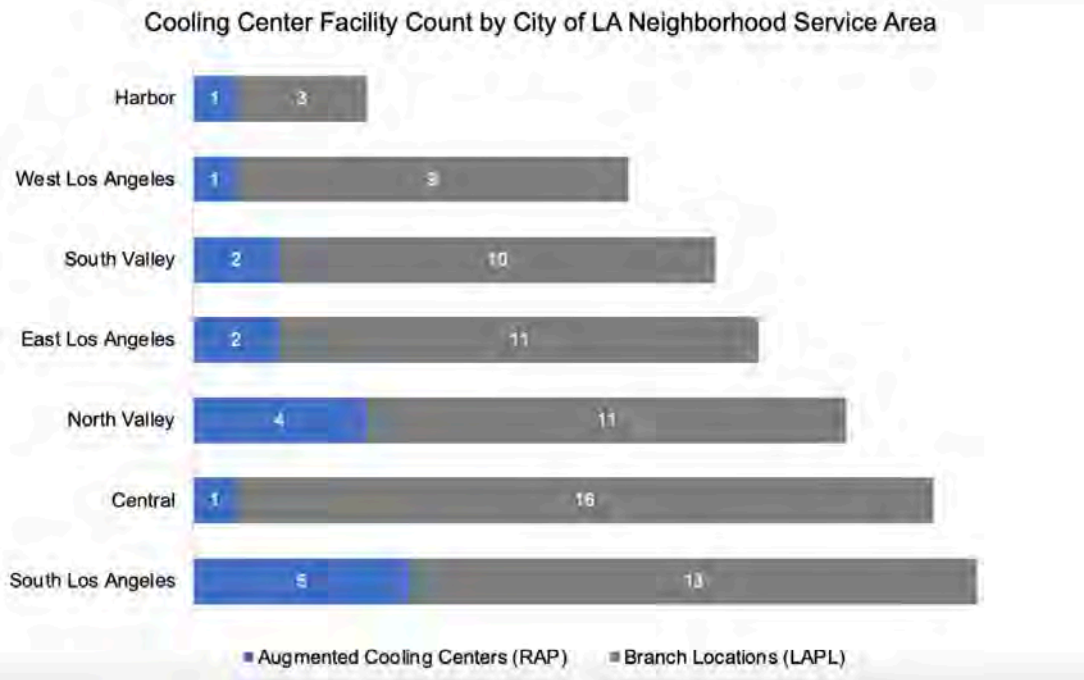


Figure 15: Sensitivity in the South Valley and one mile buffers around LAPL branch locations and RAP augmented cooling centers



This Dark Spots Analysis can be used to inform decision-making about which cooling centers should be activated during future periods of extreme heat, which should be targeted for increased capacity and capabilities, and which communities would benefit from additional facilities as extreme heat becomes more common in Los Angeles. In particular, neighborhoods facing multiple social vulnerabilities to heat should be prioritized for investments, including unhoused populations, outdoor workers, lower-income households, people of color, renter households, seniors, children, people with disabilities, individuals without health insurance, and households without access to a car. These areas also face increased heat exposure and health risks that are exacerbated by the built environment, including formerly redlined neighborhoods, homes without air conditioning or weatherization, lack of tree canopy, shade and bus shelters, and exposure to high rates of air pollution.

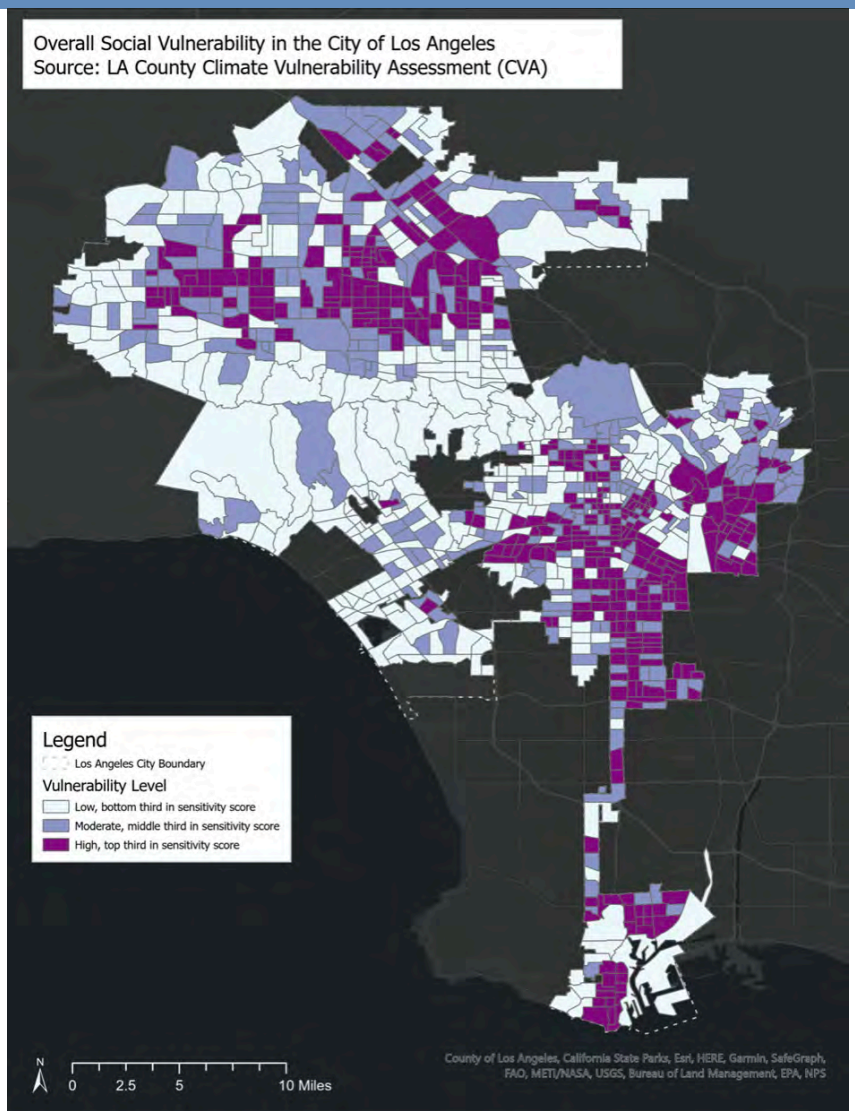
Figure 16: Cooling center facility counts per City of Los Angeles neighborhood service area



Compared to the raw social vulnerability scores in the Los Angeles County Climate Vulnerability Assessment (CVA), the results of our Dark Spots are fairly similar, with a few exceptions. In both analyses, the San Fernando Valley, East Los Angeles, and South Los Angeles emerge as areas of the city that are and will continue to be prone to the negative effects of climate change, including extreme heat. Our Dark Spots Analysis suggests that West Los Angeles is largely not an area of concern, with the

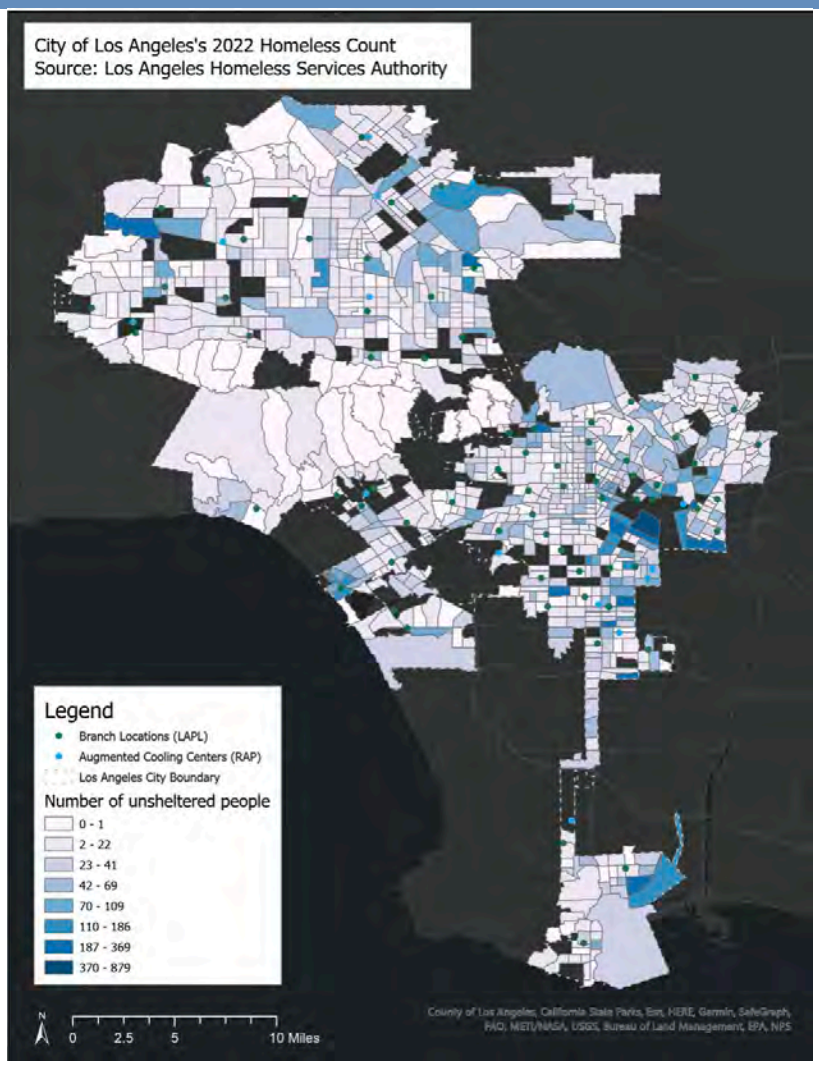
exception of a small portion of the Westchester neighborhood close to Los Angeles International Airport. Furthermore, according to the CVA, Harbor Gateway, San Pedro, and Wilmington (the city's southernmost neighborhoods) are in the top third of sensitivity scores. Although both these areas also stood out in our Dark Spots Analysis, they did not score as highly as other parts of the city such as Boyle Heights, El Sereno, Manchester Square, Gramercy Park, Downtown Los Angeles, Eagle Rock, Encino, Northridge, and Woodland Hills. With 29 total sensitivity indicators and the inclusion of community adaptive capacity variables, the CVA is a valuable county-wide tool. In contrast, the index created for our Dark Spots Analysis is tailored to our focus on extreme heat and our examination of the City of Los Angeles' cooling center network.

Figure 17: Overall social vulnerability (according to the LA County Vulnerability Assessment) within the City of Los Angeles based on vulnerability level



As mentioned previously, the CVA excludes homeless count data, which we determined to be essential to include given the heightened vulnerability of unhoused communities to extreme heat. Visualization of LAHSA's 2022 homeless count data indicates more unhoused individuals are concentrated in areas including Downtown Los Angeles, Boyle Heights, Lincoln Heights, South Central, Hollywood, Venice, Wilmington, Van Nuys, North Hollywood, Sun Valley, Pacoima, Sylmar, and Chatsworth. Although collected on three different days in January 2022, the data cannot capture the transient nature of unhoused communities often due to forced removal. Nevertheless, this data could be helpful in identifying priority locations for mobile cooling centers, particularly in areas lacking access to nearby cooling centers such as Downtown, Historic South Central, and the southern portion of Boyle Heights.

Figure 18: City of Los Angeles' 2022 unsheltered adult persons count as reported by the Los Angeles Homeless Services Authority



RECOMMENDATIONS & NEXT STEPS

Per our research findings, we provide the following nine recommendations (with detailed sub-recommendations) to CEMO and the City of Los Angeles in order to address the critical need for timely, accessible, and affordable cooling to protect health and safety when extreme heat hits Los Angeles. City-owned and operated cooling centers provide an important frontline defense against extreme heat exposure across Los Angeles, yet should be improved and expanded to best serve heat-burdened communities that rely on them for air conditioning and other resources. Our research has also reinforced that official cooling centers have a limited capacity to provide heat refuge in a city of four million residents, and improvements to cooling center network operations should be paired with other interventions to reduce barriers to accessible cooling and reach those who need it the most – where they need it the most.

Recommendation 1: Expand beyond the traditional cooling center model toward a community resilience center model that supports climate-vulnerable communities

Because cooling centers are multi-functional City facilities that provide a variety of programs and resources to residents, they are well-positioned to transition into community resilience centers. Per our site visit findings, Miriam Matthews Branch and Alma Reaves Woods Branch meet at least 10 of the 15 criteria set by the Strategic Growth Council's Community Resilience Center grant program. If other LAPL sites also retain similar features and amenities, many more library branches carry the potential to become CRCs. Although not included in our site visits, the City should also consider the suitability of augmented cooling centers to become community resilience centers, such as Green Meadows Recreation Center in South Los Angeles. CRCs rely on strong community ties to foment trust and greater social cohesion, both of which are integral in bolstering emergency response operations in frontline communities. As indicated by our dark spots analysis, neighborhoods facing heightened social and environmental vulnerability could be prioritized for CRC siting and investments.

While functional HVAC systems are crucial for existing cooling centers, our qualitative data also indicates that cooling center services must expand beyond A/C to include increased seating, water, and first aid as critical resources found at all sites. Based on demographic shifts during extreme heat emergencies that include families, elderly and unsheltered individuals, there is an opportunity to ensure all visitors have access to additional resources such as accommodations for disabilities, mental health services, and housing resources. Moreover, existing cooling centers are ideal sites to provide grab-and-go items for personal heat protection, such as handheld fans, water bottles, and cold compresses – supplies that are especially critical for unhoused populations.

Residents of vulnerable communities must be at the forefront of discussions and plans to enhance cooling centers and related resources, which opens an opportunity to expand partnerships with local CBOs and mutual aid organizations to grow offered resources, which can also help cooling center staff with additional resources and capacities to assist visitors and operate cooling centers/community resilience centers.

Recommendation 2: Expand access broadly to affordable and energy-efficient residential cooling for low-income and disadvantaged households

When the heat index reaches dangerous levels, ensuring equitable access to heat relief in homes and neighborhoods is imperative to protecting the lives of Angelenos facing high exposure and vulnerability to extreme heat. While cooling centers are an important part of the city's extreme heat resilience infrastructure, the City should also explore avenues to expand in-home cooling solutions that prioritize heat-burdened households in low-income and historically redlined neighborhoods.

Cooling centers serve as a last resort measure for households and families lacking access to other cooling options during a heat wave. While some households have no air conditioning at all, some may have small or inadequate units, and others may not be able to afford the energy costs associated with running in-home air conditioning. Barriers to accessing residential cooling should be addressed to decrease reliance on public facilities and ensure safe temperatures inside homes. Mandates to require air conditioning in rental units, as well as increased funding and outreach of existing

programs, should be considered to scale accessibility and public awareness of in-home cooling options. For example, the City of Los Angeles has currently earmarked $2 million in climate equity funds to distribute air conditioning to low-income households.[40] LADWP also operates the Cool LA program, designed to provide rebates on energy efficient cooling technology as well as offer flexible billing options to defray high energy costs over a 12 month period.[41]

Recommendation 3: Develop relationships with unhoused communities and mutual aid organizations to co-develop heat responses that meet the needs of unhoused residents

Unhoused Angelenos face dangerous and possibly deadly conditions when extreme heat descends upon Los Angeles. As noted by Theo Henderson of We the Unhoused, traditional cooling centers run by the City of Los Angeles are not regarded as welcoming sites for unhoused people to find refuge from the heat. Instead, Theo has suggested that City agencies like CEMO can partner with unhoused people and mutual aid groups to identify strategies that meet unhoused residents where they are and work to address immediate needs during heat waves. This may include strategizing on how mutual aid groups can be better resourced to take the lead and operate mobile cooling stations for unhoused communities across Los Angeles independently of City-run cooling centers.. Such strategies will require the City to think beyond the traditional cooling center model in an effort to protect health and safety and reduce barriers to cooling access for unsheltered Angelenos.

Recommendation 4: Explore strategies to informally or semi-formally expand Los Angeles' cooling centers network to include various facility types

Per our conversations with LADWP, the City could explore the feasibility of an

40 Los Angeles Mayor's Office of Energy and Sustainability, personal communication, March 2, 2023

41 Los Angeles Department of Water and Power. "Cool LA." https://www.ladwp.com/ladwp/faces/ladwp/residential/r-financialassistance/r-fa-assistanceprograms/r-fa-ap-coolla;jsessionid=x7Fbkq-6JbLJFm3v86Fhf63V5Ds2n5xVVppDCFTnlLb2TyZ3xfXfT!-1118139100?_afrLoop=2767792467377 47&_afrWindowMode=0&_afrWindowId=null#%40%3F_afrWindowId%3Dnull%26_afrLoop%3D276779246737747%26_afrWindowMode%3D0%26_adf.ctrl-state%3Dr7sxmht3y_4

incentive strategy to expand cooling center activations to private businesses and institutions. This concept could entail a memorandum of understanding between the City and other institutions such as nonprofit organizations and private shopping centers to operate as cooling centers during extreme heat events. Moreover, any City-owned and operated museums and indoor attractions could offer free admission on high-heat days as an added option for community members. Free public transit and/or shuttle service could also reduce barriers to access and encourage residents to take advantage and beat the heat.

Recommendation 5: Prioritize new cooling and resilience center locations, existing center upgrades, and future activations in the South Valley, North Valley, and East Los Angeles

LAPL's branch locations and RAP's augmented cooling center sites are relatively well distributed across the city of Los Angeles and the overall extent of their geographic coverage is large. However, there is noticeably less density of cooling center sites in the South Valley and North Valley, communities that emerged as the two highest need areas according to the criteria in our Dark Spots Analysis. Portions of neighborhoods such as North Hollywood, Sun Valley, Arleta, Mission Hills, Van Nuys, Lake Balboa, Northridge, and Canoga Park in the San Fernando Valley fall outside of the one-mile cooling center buffers. Other critical neighborhoods lacking cooling centers within a one-mile radius include Glassell Park, El Sereno, and Gramercy Park. The analysis can also be used to guide decision making about which cooling centers should be activated during future periods of extreme heat and help create a priority list of sites that should receive infrastructural upgrades.

Alma Reaves Woods and Miriam Matthews Library Branches, sites being considered for the City of LA's community resilience center grant application to the State of California, and Green Meadows Recreation Center, an augmented cooling center with solar panels and soon to receive a battery energy storage system, are all located in South Los Angeles, which is an area with heightened sensitivity but not the highest according to our analysis. Based on our findings, the North Valley, South Valley, and East Los Angeles should also be serviced by community resilience centers in the future. All three service areas have existing LAPL and RAP facilities that should also be considered and assessed for resilience center adaptation.

Recommendation 6: Streamline communications between City agencies, cooling center sites, and residents to optimize operations and increase community outreach

Communication between City agency staff who oversee heat emergency plans and individual site staff who operate cooling center locations can be improved. Discussion of extreme heat procedures is vital to operating and improving cooling center resources both for staff and visitors, yet LAPL and RAP sites indicate extreme heat procedures are discussed no more than once a year. Strategies to increase extreme heat preparedness can be implemented by senior management and implemented across sites to ensure staff and sites are well prepared during extreme heat emergencies. Internal communication on public outreach methods can also be improved, as survey responses indicate a lack of clarity from sites on who is responsible for cooling center outreach. Cooling center outreach largely falls on the City and LAPL as a whole, but individual branch outreach varies site-by-site. Internal coordination on outreach responsibilities between individual sites and City agencies can be further examined to expand outreach to visitors.

Moreover, because each cooling center is unique, individual sites should engage in targeted and culturally-informed outreach to publicize cooling centers activations. Our survey data reveals multiple languages are spoken at most sites, but many of these languages are not supported by staff. This calls for further examination of which languages are spoken by visitors and how they can be supported by site staff, as well as outreach strategies to engage multilingual communities. Social media was the exclusive outreach tool used by RAP, and the most used by LAPL sites. However, other outreach methods such as physical advertising (e.g., banners, fliers) and word-of-mouth should also be utilized, as social media may not be the most effective outreach method when considering various degrees of computer literacy and access to the internet.

Recommendation 7: Ensure HVAC systems are maintained and upgraded at existing cooling centers, and offer portable cooling supplies such as handheld fans and cold compresses

LAPL and RAP cooling centers provide air conditioning as a key function of their sites. Deficiencies in HVAC system reliability and functionality were raised several times throughout our analysis, particularly in our qualitative data. Given that reliable A/C is paramount to the operations of a cooling center, updating older HVAC systems and maintaining current units is essential to continue providing on-site cooling to the public. Potential recommendations include:

- Create an inventory of cooling installations (e.g., air conditioning, weatherization) at libraries and augmented cooling centers to identify sites in need of repairs or upgrades.
- Conduct regular maintenance and inspections of HVAC systems, particularly in advance of the high-heat season, to ensure units are functioning.
- Measure repair/service response times during cooling center activations, which can be critical during extreme heat emergencies.
- Identify funding sources to invest in HVAC upgrades and replacements.

Recommendation 8: Collect improved visitor data for existing cooling centers and bolster infrastructure and capabilities in facilities with higher rates of usage

Visitor count data from the late-summer 2022 heat wave provided some insight into levels of usage, but only for the sites activated during that period. Similar data for other cooling center activation periods was never collected at LAPL or RAP sites. Although distinguishing between regular patrons and cooling center patrons is not feasible, better year-round data on visitor counts alone would allow researchers to detect patterns in usage by comparing counts on days with elevated temperatures to days with more mild ones. Recommendations could then be made regarding which facilities are more heavily used and might benefit from expanded capabilities and infrastructure upgrades, such as those related to community resilience centers. As summer 2023 approaches, now is a good time to begin collecting visitorship data across LAPL and RAP sites.

Recommendation 9: Implement more individualized solutions based on organization, site location, and needs of visitors

Our research has uncovered that potential benefits for one agency may not apply for another. LAPL and RAP cooling centers each have distinct structures and operations. Within this, each site also has diverse visitors and unique needs. Due to this variation across sites, any large-scale recommendations that will be standardized across the City's cooling center operations must be further consulted with RAP and LAPL sites. This recommendation has been influenced by differing responses across the two agencies: for example, while RAP indicated that adding more staff and extending operating hours would be helpful, the majority of respondents at LAPL sites indicated that more staff on site or extension of hours would not be helpful.

Limitations

This research effort has faced a number of limitations that provide the basis for further investigation in the future. For context, the MURP Comprehensive Project is an unfunded, time-limited research project, which vastly limited the data collection and analysis methods we were able to employ. Of particular note, our data collection did not align with cooling center activation periods. Since the community resilience center model, and semi-formal cooling center network concepts, are in nascent stages within the City of Los Angeles, ongoing research and evaluation will be required to assess developments and impact over time. Due to the unique structures of LAPL and RAP-operated cooling centers, different data collection tools may have been better suited to encapsulate cooling center experiences, particularly for Recreation and Parks, as there was a lack of survey data available for RAP that may have been better collected through individual site responses. Survey data responses were limited, as not all cooling center sites participated in the survey. Moreover, there was insufficient time to conduct thorough and additional follow up interviews with survey participants, CBOs, community residents, and advocates for unhoused people. This study also faced limitations from incomplete or unfulfilled data availability from some units of the City of Los Angeles, such as lack of door counts and building capacity limits for library branches. Lastly, the MURP Comprehensive Project is an unfunded, time-limited research project, which vastly limited the data collection and analysis methods we were able to employ.

Relatedly, some vital elements that must be considered and implemented are out of the team's expertise and project scope. In particular, more direct consideration of and interaction with communities most affected by heat inequity, such as unhoused residents and their experiences, is necessary to inform true solutions. Resident voices must be respected and centered in order to implement and find potential solutions that can uplift communities and truly provide protection from extreme heat.

CONCLUSION

Cooling centers are one important part of the solution which the City of Los Angeles is scaling up to help communities deal with the impacts of extreme heat events. However, cooling centers–public spaces that are air-conditioned, such as libraries and recreational facilities–are often left empty during extreme weather conditions. In 2020, a heatwave in Los Angeles brought several neighborhoods into triple-digit temperatures and resulted in over XX deaths. Despite these conditions, fewer than 300 people visited one of the six cooling centers that were set up in the county.[42] Each cooling center averaged 11 visitors per day, except for a center located in South L.A., which had no visitors. With the understanding that cooling centers must first meet the needs of community members, resilience hubs are a compelling alternative given that they aim to provide"established, trusted, and community-managed facilities that are used year-round as neighborhood centers for community-building activities".[43] Using the resilience hub framework allows for an intersectional climate resilience that understands that it will take more than cooling to make a space resilient to climate change impacts. Resilient hubs are the ultimate amenity for communities to deal with climate change impacts. Since they are built in places that are already trusted by the community, existing conditions are elevated to support this.

With the addition of the key components to resilience hubs mentioned above and other amenities needed, Los Angeles Public Libraries and Rec & Park sites could increase a community's capacity to deal with climate change impacts and emergencies and increase social cohesion. However, many community members,

42 Reyes, Emily Alpert. "L.A. Suffered Deadly Heat, Yet Chairs Sat Empty at Its Cooling Centers." Los Angeles Times, Los Angeles Times, 19 Sept. 2020, https://www.latimes.com/california/story/2020-09-19/la-deadly-heat-empty-cooling-centers.

43 Network, Urban Sustainability Directors. "Urban Sustainability Directors Network." USDN, https://www.usdn.org/resilience-hubs.html.

such as unhoused individuals, have shared that they are hesitant to visit cooling centers during extreme heat events due to concerns around privacy, policing, surveillance, storage, and pet accommodations for example. This necessitates an increase in auxiliary cooling services (such as mobile air conditioning units, fans, misters, etc.) by the City and trusted community partners to meet unhoused community members where they are at, whether it be organized encampments, shelters, sidewalks, or parks.

Our cooling center research represents one element of a multipronged approach to addressing extreme heat in the City of Los Angeles, which is echoed in this larger report. By collaborating with the Bus Shelters and Emergency Data Management Teams, we have developed a broader body of research and extensive institutional knowledge to mitigate key environmental and public health concerns for Los Angeles' most marginalized communities. We hope that CEMO, City of Los Angeles stakeholders, and community partners will be able to leverage this research to make Los Angeles a more healthy, safe, cool, and equitable city to live, work, commute, and thrive in as extreme heat becomes the new normal.

ACKNOWLEDGEMENTS

The authors would like to thank thank the following stakeholders, organizations, and individuals for their support and participation in the development of this chapter:

- Dr. Greg Pierce & Dr. Ruth Engel
- Los Angeles Climate Emergency Mobilization Office (CEMO)
- Los Angeles Public Library (LAPL)
- Los Angeles Department of Recreation and Parks (RAP)
- Los Angeles Department of Water and Power (DWP)
- Los Angeles Emergency Management Department (EMD)
- Los Angeles Mayor's Office of Energy and Sustainability
- Los Angeles County Chief Sustainability Office
- Los Angeles Regional Collaborative for Climate Action and Sustainability (LARC)
- We the Unhoused

REPORT APPENDICES

Appendix A

Incident Counts for Top 10 Fire Districts, 2018-2022

Year	Fire Districts	Total Incident Counts
2018	9	18900
	64	13536
	66	11459
	57	11283
	11	9916
	46	9669
	33	8635
	51	8100
	89	7752
	27	7613
2019	9	20263
	64	13602
	57	11772
	66	11666
	11	10656
	46	9472
	33	9048
	51	8576
	89	8104
	27	7976
2020	9	17385
	64	14251
	57	11557
	66	11423
	11	11194
	46	9820
	33	9711
	89	8201
	39	7114
	98	6987

Incident Counts for Top 10 Fire Districts, 2018-2022

Year	Fire Districts	Total Incident Counts
2021	9	18574
	64	14190
	66	12011
	11	11967
	57	11727
	46	10122
	33	9666
	89	8609
	27	8105
	10	7440
2022	9	20491
	64	14695
	11	14225
	66	12101
	57	12045
	46	10143
	33	9857
	89	9556
	27	8508
	4	8411

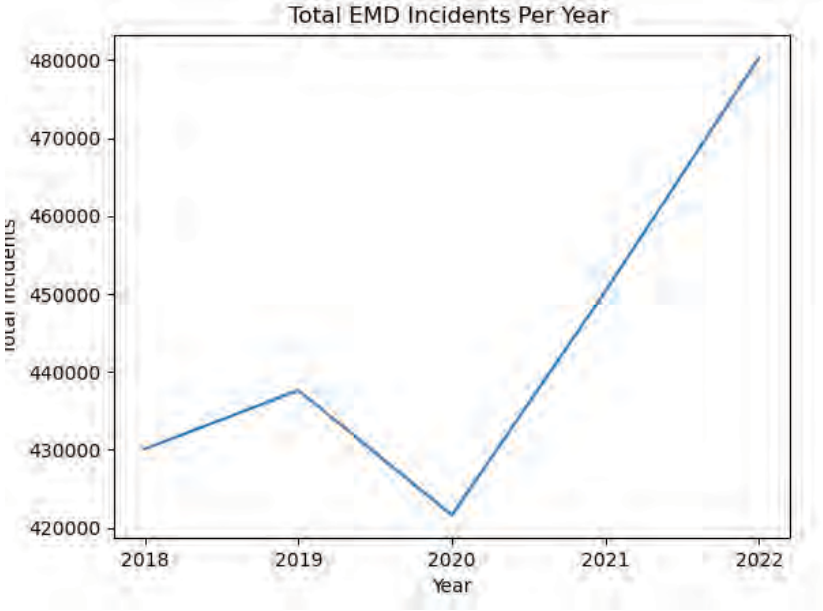
Appendix B

CVA Variables Not Used in Our Analysis

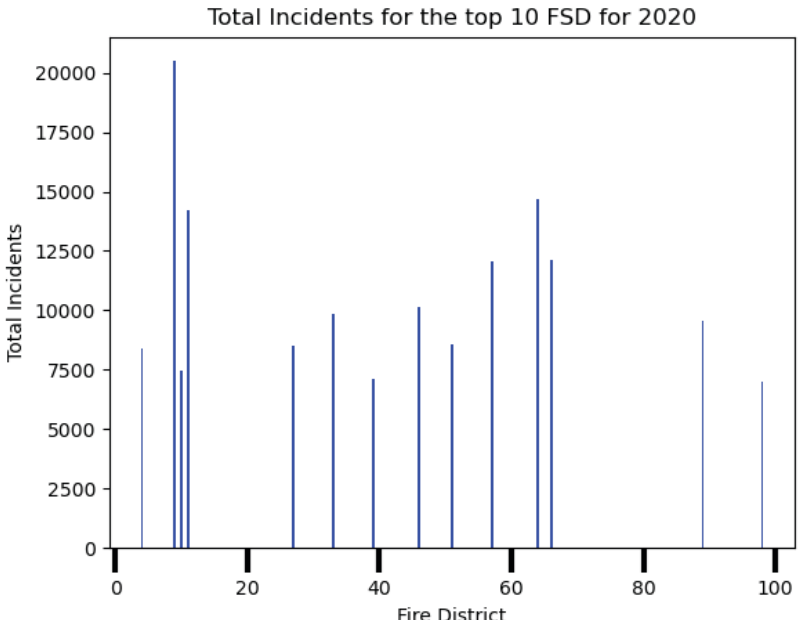
Variable	Definition
Asian	Percent identifying as non-Hispanic Asian
Black	Percent identifying as non-Hispanic black or African American
Female	Percent female
Female householder	Percent of households that have a female householder with no spouse present
Foreign born	Percent of the total population who was not born in the United States or Puerto Rico
Hispanic Latinx	Percent identifying as Hispanic or Latino
Households without vehicle access	Percent of households without access to a personal vehicle
Library access	Each tract's average block distance to nearest library
Limited English	Percent limited English speaking households
Median income	Median household income of census tract
Mobile home	Percent of occupied housing units that are mobile homes
No high school diploma	Percent of persons 25 and older without a high school diploma
No internet subscription	Percent of the population without an internet subscription
Transit access	Percent of population residing within a ½ mile of a major transit stop
Tribal and Indigenous	Percent identifying as non-Hispanic American Indian and Alaska native
Unemployed	Percent of the population over the age of 16 that is unemployed and eligible for the labor force
Voter turnout rate	Percentage of registered voters voting in the 2016 general election

Appendix C

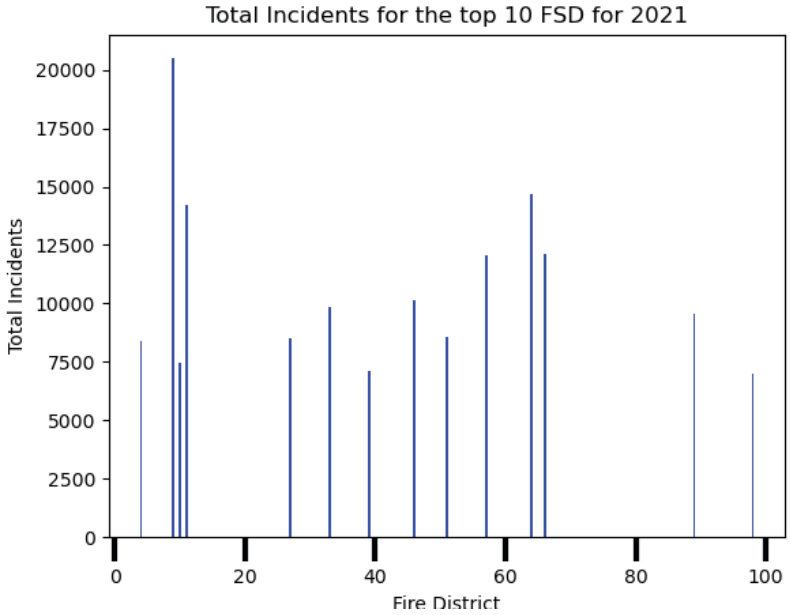
Total 911 Calls per Year



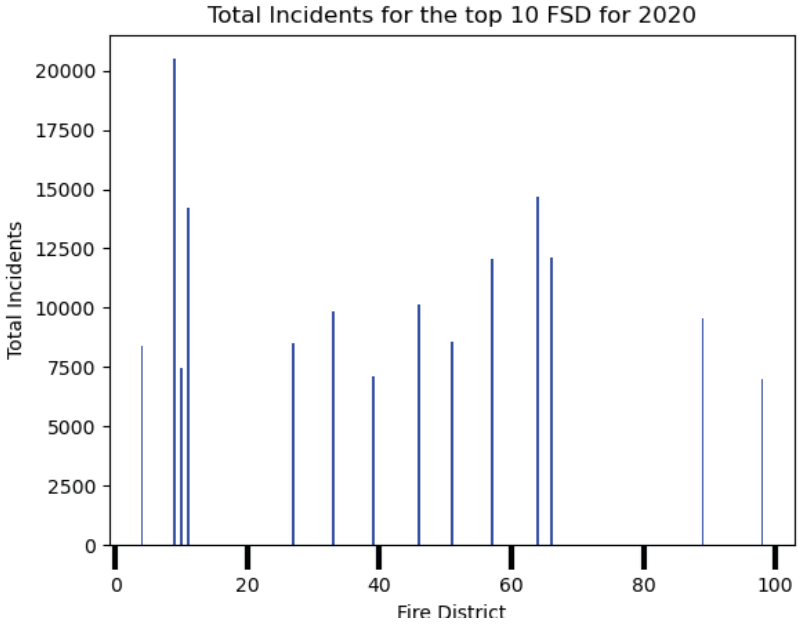
Total Incidents of the Top 10 FD, 2022



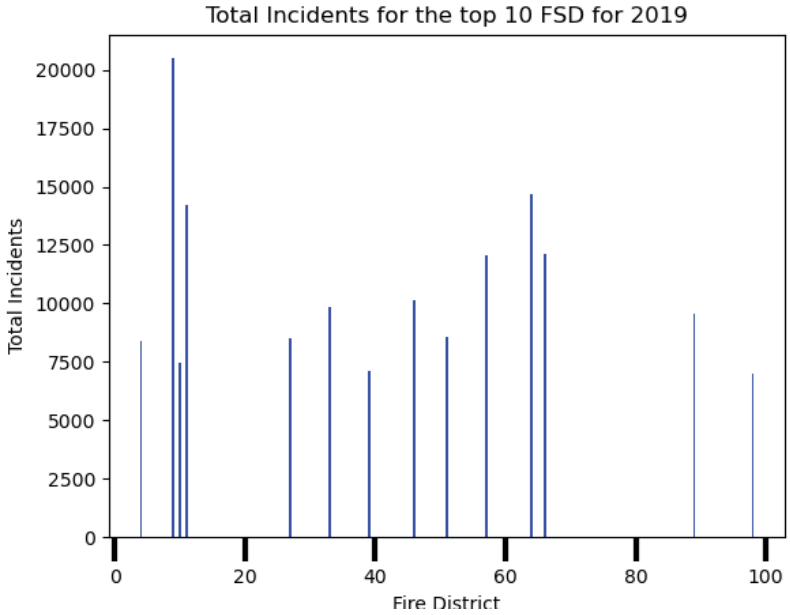
Total Incidents of the Top 10 FD, 2021



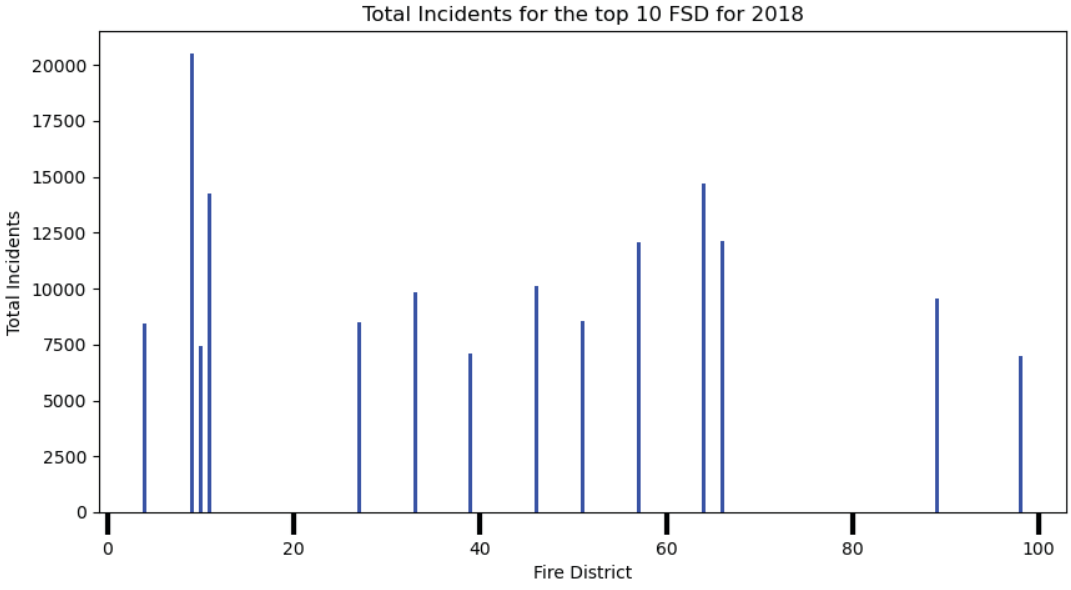
Total Incidents of the Top 10 FD, 2020



Total Incidents of the Top 10 FD, 2019

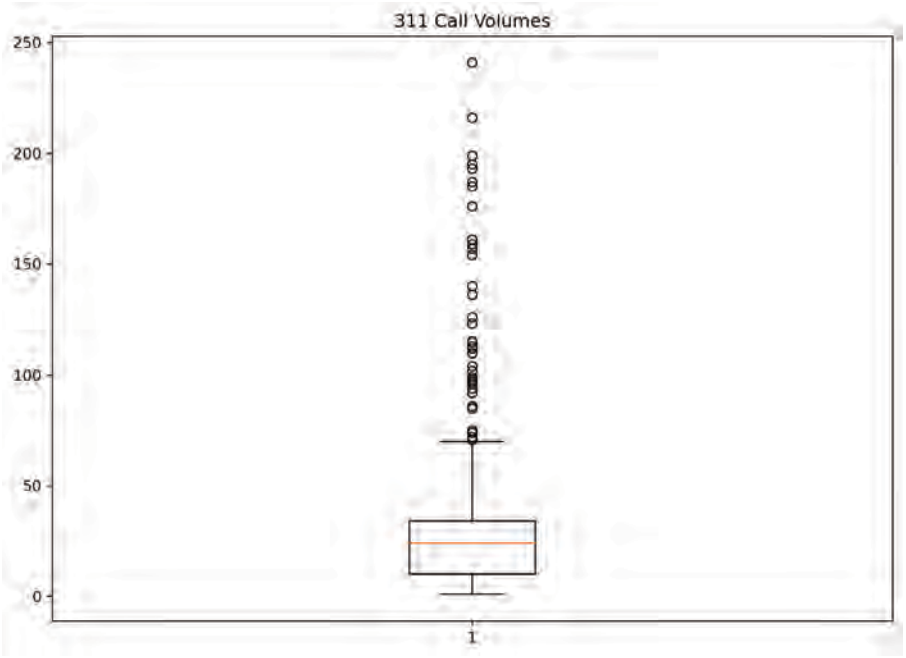


Total Incidents of the Top 10 FD, 2018

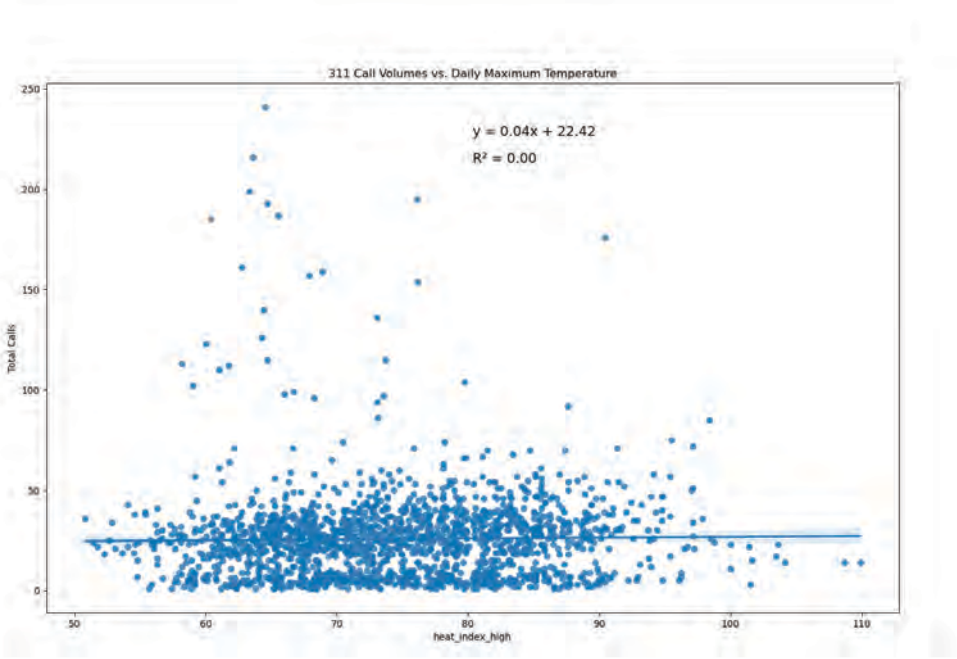


Appendix D

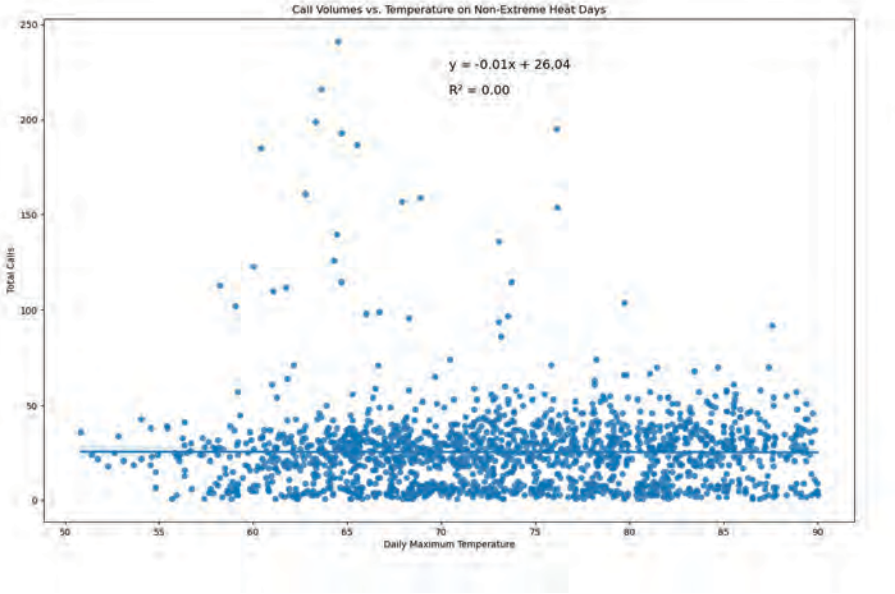
311 Call Volumes Distribution



311 Call volumes vs Daily Max Temperature

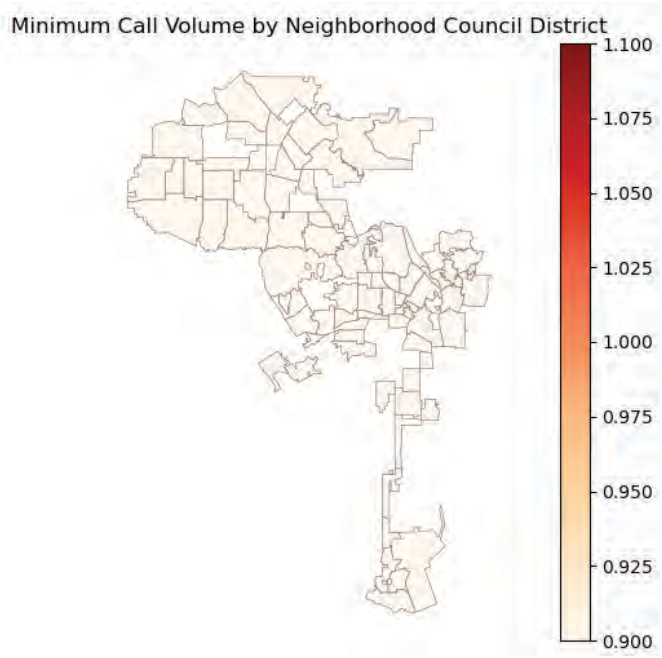


Call Volumes vs Temp on Non-Extreme Heat Days

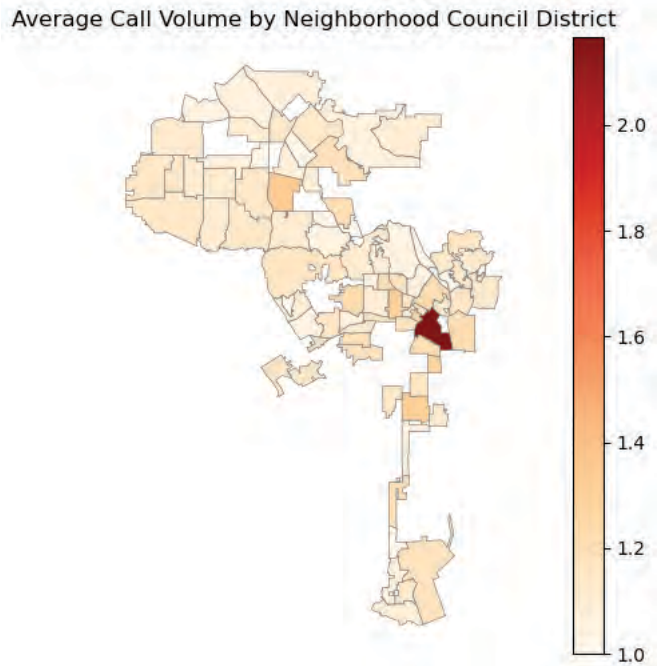


Appendix E

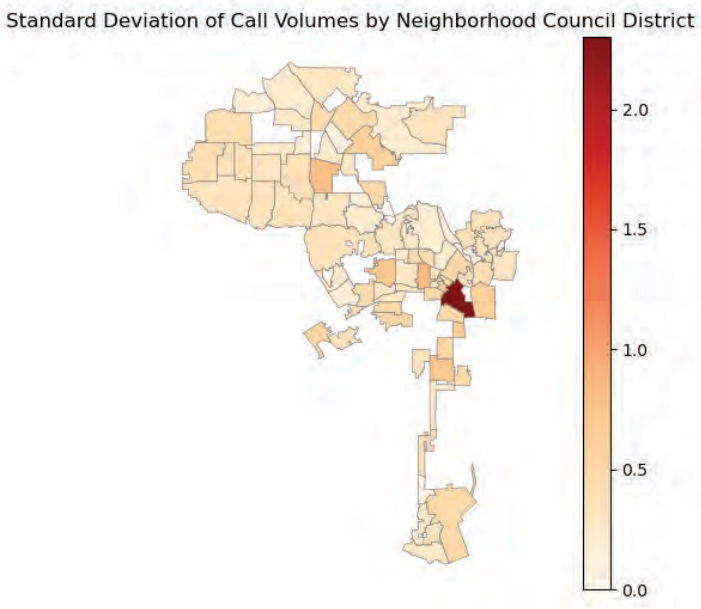
Minimum Call Volume



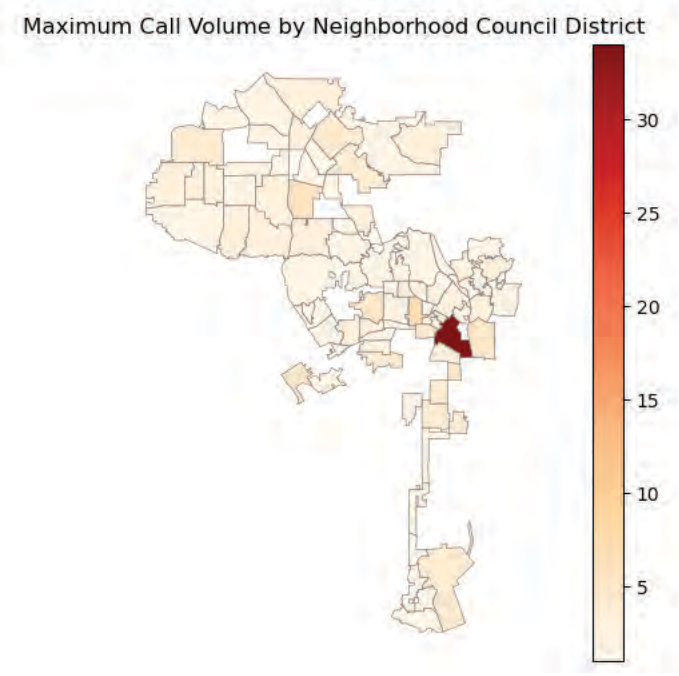
Average Call Vollume



Standard Deviation of Call Volume

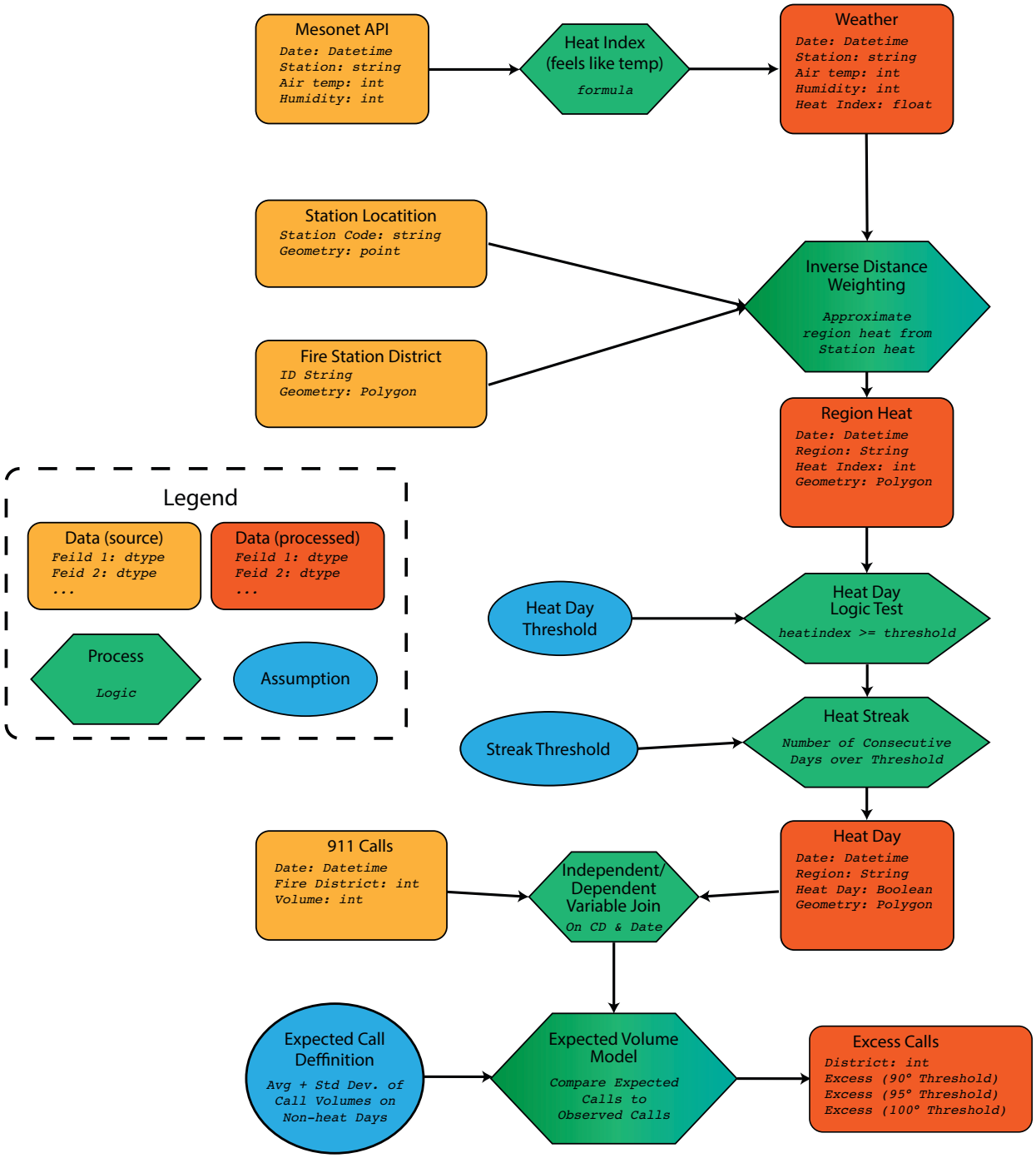


Maximum Call Volume



Appendix F

Excess Call Process Flowchart



APPENDIX (A-F)

Appendix A: Cooling Center Staff Survey

The table displays questions by theme, highlights our analysis plans, and shows distribution.

Category	Question	Distribution	Coding
Accessibility	"Is your site ADA compliant and accessible?"	☐ Recreation & Parks ☐ LAPL	Quantitative, as an inventory
	"Are you, or any of your staff, trained in emergency response (e.g., first aid, CPR)?"	☐ Recreation & Parks ☐ LAPL	Quantitative, as an inventory
	"What are common languages spoken at your site by visitors, and are they supported by staff?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"What are some constraints or difficulties in how visitors access your site?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"Is your site pet-friendly (including non-service animals) during normal operating hours and during extreme heat days?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"What additional resources at your site would be beneficial on extreme heat days?"	☐ Recreation & Parks ☐ LAPL	Qualitative
Programming/ Services Offered:	"How often does your site discuss procedures related to extreme heat days?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"On extreme heat days, would a greater number of staff in the building than on "normal" weather days be helpful?"	☐ Recreation & Parks ☐ LAPL	Qualitative

	"What services related to cooling centers are offered at your site?"	☐ Recreation & Parks ☐ LAPL	Qualitative
Demographics	"During extreme heat days, do you notice a difference in who is visiting your site (e.g., different age groups, ethnoracial communities, gender, etc.)?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"Is cooling center outreach catered to specific demographic/ethnoracial groups? What groups, and is the outreach successful?"	☐ Recreation & Parks ☐ LAPL	Qualitative
Outreach	"Does your site partner with local community organizations? If so, who?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"What outreach methods are used at your site to reach the local community regarding cooling centers?"	☐ Recreation & Parks ☐ LAPL	Qualitative
Physical Site/ Retrofitting Suitability	"How would you describe air conditioning (A/C) at your site?"	☐ Recreation & Parks ☐ LAPL	Qualitative
	"Do you think extending hours during extreme heat days would be beneficial? Is this possible for your site?"	☐ Recreation & Parks ☐ LAPL	Qualitative (opinion on if hours extension is beneficial) Quantitative (inventory if hours extension is possible)
Cooling Center Usage	"During extreme heat days, do you notice a difference in how often people visit your site (e.g., frequency of visitors)?"	☐ Recreation & Parks ☐ LAPL	Qualitative

	"During extreme heat days, do you notice a difference in the number of visitors coming to your site?"	▯ Recreation & Parks ▯ LAPL	Qualitative
	"During extreme heat days, do you notice a change in visitors' uses or activities at your site?"	▯ Recreation & Parks ▯ LAPL	Qualitative
	"If you answered "yes" to the previous question, what types of activities are observed on hot days?"	▯ Recreation & Parks ▯ LAPL	Qualitative

Appendix B: Further Detailed Results from LAPL Survey Responses

Underlying datasets may be provided by the research team upon request.

Programming and Site Services

- ▯ Site Services
  - 100% (39/39) of sites offer air conditioning
  - 92.3% (36/39) sites offer seating/lounging areas
  - 79.5% (31/39) sites offer drinking water
  - 43.6% (17/39) sites offer hydration stations
  - 17.9% (7/39) sites offer first aid
- ▯ Extreme Heat Procedures and Programming
  - LAPL indicated that discussions related to extreme heat procedures are not often discussed by branch, so they are not measurable
- ▯ Staff
  - 59% (23) sites indicated that a greater number of staff present during extreme heat days would not be helpful
  - 28.2% (11) sites indicated that a greater number of staff present during extreme heat days would be helpful
  - 3 respondents indicated that it would be helpful for purposes of security

Physical Site

- AC Reliability and Functionality
  - 46.2% (18 respondents) directly indicated that the AC works great and feels cool during normal and hot days
  - 33.3% (13 respondents) directly indicated that the AC works great on normal days, but not during hot days
  - (3 respondents) indicated that the AC works great during both instances, but is unreliable and has failures
  - (1 respondent) indicated that the AC does not work on either type of day
- Additional Resources
  - 51.3% (20 respondents) indicated that outreach and communication with the public about cooling centers can be improved (including information in other languages)
  - 48.7% (19 respondents) indicated that the physical building can be improved (AC, more seating, etc.)
  - 23.1% (9 respondents) indicated that program offerings can be improved (more activities, staff)
  - 10.3% (4 respondents) indicated that providing more transportation/ shuttle options would be beneficial
  - 15.4% (6 respondents) selected all of the above would be beneficial as additional resources
  - 1 respondent stated, "It would be great to have someone that can provide mental health services / homeless support."
  - 1 respondent stated "More cooling amenities would be appreciated: cold water bottles, sanitizing wipes, sweat towels, etc."

Cooling Center Usage and Demographics

- Frequency of Usage
  - 64.1% (25 respondents) indicated that during hot days, people visit their site more often
  - 33.3% (13 respondents) indicated that they do not notice a difference in how often people visit their site during hot days
- Increase of Usage
  - 64.1% (25 respondents) indicated that they notice more visitors at the site during hot days
  - 30.8% (12 respondents) indicated that they do not notice a difference in

the amount of site visitors during hot days compared to 'normal' weather days

- Change of Usage
  - 66.7% (26 respondents) indicated that during hot days, visitors' activities do not change
  - 30.8% (12 respondents) indicated that during hot days, visitors' activities change.
  - For respondents that indicated that usage activities change:
    - 5 respondents stated that visitors use the site more casually
    - 4 respondents stated that visitors use the internet or charge their devices more
    - 3 respondents stated that visitors spend more time at the branch
    - 2 respondents stated that visitors' emotions shift negatively
- Demographics
  - 10 respondents indicated that during extreme heat days, they do not notice a change in demographics
  - 8 respondents indicated that they notice an increase of both elderly and unhoused individuals
  - Other patterns of responses indicated an increase of adults and unsheltered individuals independently

Accessibility

- ADA
  - LAPL indicated all sites must be ADA accessible
- Emergency Response
  - LAPL indicated that standard procedures do not call for LAPL staff to be trained in first response. Procedures in place rely on outside emergency response for assistance
- Language Accessibility
  - 25 respondents indicated that English and Spanish are spoken by visitors and are supported
  - Farsi, Mandarin, Korean, Tagalog, Russian, Japanese, and Vietnamese were indicated as languages spoken by visitors, but not primarily supported by staff
- Hours of Operation
  - 66.7% (26) sites indicated that extending hours would not be beneficial
  - 15.4% (6) sites indicated that extending hours would not be beneficial

- Constraints
  - 38.5% (15) sites indicated that visitors express public safety concerns about their site
  - 38.5% (15) sites indicated that there are no significant constraints for visitors at their site
  - 12.8% (5) sites indicated that their site's hours of operation are limited
  - 10.3% (4) sites indicated that accessing their site via public transportation is difficult
- Pet-Accessible
  - LAPL allows service animals only.

Outreach and Partnerships

- Outreach Methods
  - 71.8% (28) sites indicated that they use social media (Instagram, Facebook, Twitter, etc.
  - 30.8% (12) sites indicated that they use physical advertising (fliers, posters, pamphlets)
  - 12.8% (5) sites indicated that they use television for outreach
  - 5.1% (2) sites indicated that they use radio for outreach
  - 2 respondents indicated word of mouth is used for outreach
  - 6 respondents indicated outreach is done by the city or LAPL
- Outreach Demographics
  - 16 respondents indicated that outreach is not catered towards any particular demographic
  - Other respondents indicated it is catered towards local communities to the branch, seniors or unsheltered residents
- Partnerships
  - Neighborhood Councils, schools, mental health departments

Appendix C: RAP Staff Survey Results

As noted above, there are 16 augmented cooling centers under the discretion of the Department of Recreation and Parks. We received 16 responses, but they were all filled out largely by a single Recreation and Parks staffer. This is important to note as in comparison to LAPL, LAPL distributed the survey to library sites directly for each branch to fill out directly.

Below, we provide a summary of highlights found from each category and questions

under category. We discuss trends:

Programming and Site Services

Data shows that all 15 sites offer air conditioning, and 14/15 sites offer drinking water, first aid, seating and lounging areas. Most augmented sites offer expanded amenities, with a potential opportunity to expand offerings via hydration stations. Data from the survey indicated that extreme heat procedures are discussed annually, which can be expanded to more recurring discussions to ensure staff and visitors have necessary resources for extreme heat mitigation. An increase in discussion of extreme heat related procedures may also benefit staff and site capacity to serve as a resource for visitors, especially the change in demographics during extreme heat days, as 100% of sites indicated that families and unhoused people use the site more during extreme heat days.

RAP sites indicated that more staff during extreme heat days would be helpful, which should be considered as resources during extreme heat days may be strained, and may better support other staff and cooling center users.

Physical Site

Data for all sites described AC as both reliable and functional during both day types, and data for all sites also indicated that the physical building, outreach and communication, program offerings and transportation options could be improved.

Cooling Center Usage and Demographics

Data from all sites indicated that there was no difference in frequency or change in visitors' activities during extreme heat days, yet all sites indicated that there is an increase in visitors during extreme heat days. Based on cooling center usage patterns, the indication of an increase in visitors during hot days is in line with data showing that more staff on site during extreme heat days would be beneficial as to support the increase in numbers. Data on demographic changes during extreme heat days indicated that all sites noticed an increase of families and unhoused residents.

Accessibility

All RAP augmented sites were noted as pet friendly, ADA compliant, and indicated to have someone on their staff who is trained in emergency response, yet the extent of emergency training and staff capacity for emergency response can be

further investigated. Data on language accessibility indicated English and Spanish as the most common languages spoken by visitors and supported by staff. Hours of operation were indicated as beneficial and possible by data from all sites. Data from all sites stated that there were no constraints in how visitors access their site.

Outreach and Partnerships

The exclusive outreach method used to reach local communities is social media, and data indicated outreach is not catered to a specific demographic. Based on trends that indicate that families and the unhoused community are two of the most prominent demographics during extreme heat days, outreach especially towards those two groups may be beneficial to ensure communities who currently are utilizing cooling centers continue to benefit from cooling center resources. On the other hand, future outreach to other groups may provide more insight, and possibly reach other demographics that may be in need of this resource, but are currently unaware or remain unused. Survey responses highlighted partnerships with Animal Services, the Emergency Management Department, the Department on Disability, and the Department of Water and Power.

Datasets may be provided upon request.

- Programming and Site Services

  Site Services
  - 100% (15/15) of sites offer air conditioning.
  - 93% (14/15) of sites offer drinking water, first aid, seating/lounging areas.
  - 0% offer hydration stations.

  Extreme Heat Procedures and Programming
  - 100% of sites indicated they discuss procedures related to extreme heat annually.

  Staff
  - 100% of sites indicated that a greater number of staff present during extreme heat days would be helpful.

- Physical Site

  AC Reliability and Functionality
  - 100% (15/15 of the sites) are described to have reliable air conditioning systems that function on ‘regular’ AND ‘hot weather days’.

Additional Resources

- 100% of sites indicated that the physical building (AC, more seating, etc.), outreach and communication with the public about cooling center (including information in other languages), program offerings (more activities, staff), and transportation options could be improved.

- Cooling Center Usage and Demographics

  Frequency of Usage

  - 100% of sites indicated that during extreme heat days, they don't notice a difference in how often or how frequent people visit their site.

  Increase of Usage

  - 100% of sites indicated that during extreme heat days, they notice an increase in visitors at their site.

  Change of Usage

  - 100% of sites indicated that during extreme heat days, they do not notice a change in visitors' uses or activities at the site.

  Demographics

  - 100% of sites indicated that during extreme heat days, they notice a difference in demographics of visitors, as 'families and people experiencing homelessness come in.'

- Accessibility

  ADA

  - 100% of sites are ADA compliant and accessible.

  Emergency Response

  - 100% of sites indicated that someone on their staff is trained in emergency response (e.g., first aid, CPR).

  Language Accessibility

  - 93% (14/15) of sites indicated that 'English and Spanish' are common languages spoken by visitors, and are supported by staff.
  - 7% (1 site) indicated that 'English, Spanish and Tagalog' are common languages spoken by visitors, and are supported by staff.

  Hours of Operation

  - 100% of sites indicated that extending hours during extreme heat days would be both beneficial and something that is possible at the site.

Constraints

- 100% of sites indicated that there are no constraints or difficulties in how visitors accessed their site.

Pet-Accessible

- 100% of sites indicated that their site is pet friendly during regular and extreme heat days.

- Outreach and Partnerships

Outreach Methods

- 100% of sites indicated that 'social media' was the exclusive outreach method used to reach local communities regarding cooling centers.

Outreach Demographics

- Outreach is not catered to a specific demographic or ethnoracial group at Recreation and Parks, but responses indicate that marketing strategies can be improved.

Partnerships

- Recreation and Parks partners with Animal Services, the Emergency Management Department, the Department on Disability, and the Department of Water and Power.

Appendix D: Interview Results

LAPL - Overview of Interviews

Among those who filled out the survey and indicated interest in being interviewed, our team met with three cooling center staff members to discuss their experiences with working at library operated cooling centers and expand on their survey responses. These interviews enabled our team to further develop an understanding of cooling center experiences by some staff beyond data collection from the survey.

LAPL - Emergency Response

Although in general procedures in place at LAPL for emergencies include contacting emergency response outside of LAPL, during an interview a respondent indicated that some staff are trained in CPR, use of defibrillator and Narcan. This optional training was organized by LAPL recently, although emergency response training is not the norm and varies across branches. One respondent expressed that training for emergency help can save lives and is necessary, as "libraries should be a place where people get resources to help."

LAPL - Accessibility & Shelter

Other accessibility related discussions within the interview included the inclusion of service and non-service animals within the library. Although LAPL has strict policies in place with animals, during weather alerts there have been recent instances where restrictions are lifted, and animals have been allowed in emergency situations. During recent weather alerts, rain gear such as ponchos, towels and tarps for people and their belongings were handed out, which the respondent believes could be done during extreme heat weather events as well, providing additional resources that can aid all visitors including unhoused individuals.

The respondent discussed the heightened risks unhoused people have to heat related illnesses, and acknowledged the opportunities to offer on-site resources to the unhoused community. Although this differs by branch, the respondent discussed their branch's partnerships with other organizations and social workers from the National Health Association. Partnerships in place allow their branch to connect visitors with resources related to mental health, physical health employment and housing assistance.

LAPL - Staffing & Resiliency

As the interviews progressed, discussions of additional staff and extended hours were discussed as something that would be helpful during emergency situations such as extreme heat. Beyond extreme heat specific emergencies, the discussions about potential opportunities for their library branch used as a cooling site paralleled characteristics of a resilience hub model, as discussions during the interview expanded to other resources that could be offered, such as refrigeration and the site serving as a meeting place for people to conjugate during other emergency situations. Important highlights from interviews also include discussions of staff capacity and other resources. The respondent said that in their branch, they have enough staff, but if regular staff is unavailable, replacement or 'sub-staff' are limited, which is especially important during extreme heat weather.

LAPL - Physical Site

In relation to the physical site, we discussed both the general unreliability of HVAC systems and the library respondents' personal experiences with HVAC systems. The respondent highlighted that reliability of HVAC systems depends on the year the HVAC system was built, and that some older HVAC systems take longer to be

repaired depending on parts required, that may no longer be found in stores. The respondent indicated that HVAC system maintenance is out of scope for the library sites, and is primarily handed by the General Services Department. Although repairs and maintenance are handled by the business office, increased coordination between LAPL sites and related departments may be useful in supporting HVAC systems.
Our conversations concluded with accommodations provided for visitors, and how accommodations vary based on the visitor's particular needs. They confirmed they provide accommodations for all visitors, such as disabled or unhoused community members, but said that their staff is not often aware or able to tell if visitors are experiencing housing insecurities.

LAPL - Outreach & Partnerships

In discussions of outreach, a respondent expressed that outreach is not particularly catered towards one particular group, but stated that targeting outreach to unhoused residents and conducting outreach in other languages would be especially beneficial, via word of mouth, television and social media. Another respondent also voiced a similar sentiment that reflects both surveys and other respondents towards outreach and other general procedures. Because branches are in diverse geographical locations with unique constraints, opportunities and communities, many implementations often vary branch to branch. This is the case with outreach at their particular branch as well, as they expressed that LAPL as a system conducts the majority of outreach, but branches can also participate based on capacity and interest. In their particular location, there is a larger Spanish speaking community, so there is a push for outreach in multiple languages.

Regarding outreach and partnerships, a notable example discussed were some of the educational programming, such as programming for community members on pathways to citizenship. The respondent emphasized how social media as a sole outreach tool is not sufficient as it does not encapsulate different communities who may not be on social media or as computer literate. For residents who speak other languages and may be within immigrant communities, the respondent mentioned how 'WhatsApp' is a popular communication tool, and is a tool that could be incorporated in cooling center outreach.

Based on conversations with site staff from LAPL branches, integral procedures and aspects that support LAPL sites as cooling centers prove to be more successful

through increased communication with staff, visitors and among partnering organizations. This can be seen with outreach, as increased communication with partner organizations has allowed for additional resources to visitors to be provided such as mental and physical health support. Increased communication through outreach can also be met through improved communication with visitors, through language inclusion and further outreach inclusion through the expansion of outreach methods beyond social media, to reach those who do not have access to the internet or are not computer literate. In general, based on survey respondents and follow up interviews, there seems to be a lack of consistency in terms of how outreach responsibility is distributed, with an unclear designation of who outreach responsibilities fall on.

RAP - Summary of Interviews

Our team also met with two officials from Recreation and Parks to discuss their role in cooling center activation and coordination within their organization. This is insightful as it provides a mixed perspective at cooling center sites from a top-bottom approach, and looks at specific experiences from cooling center activations and planning, as our other qualitative survey method follows a more ground up approach that examines day to day experiences at a cooling site, both incredibly valuable.

Recreation and Parks - Emergency Response

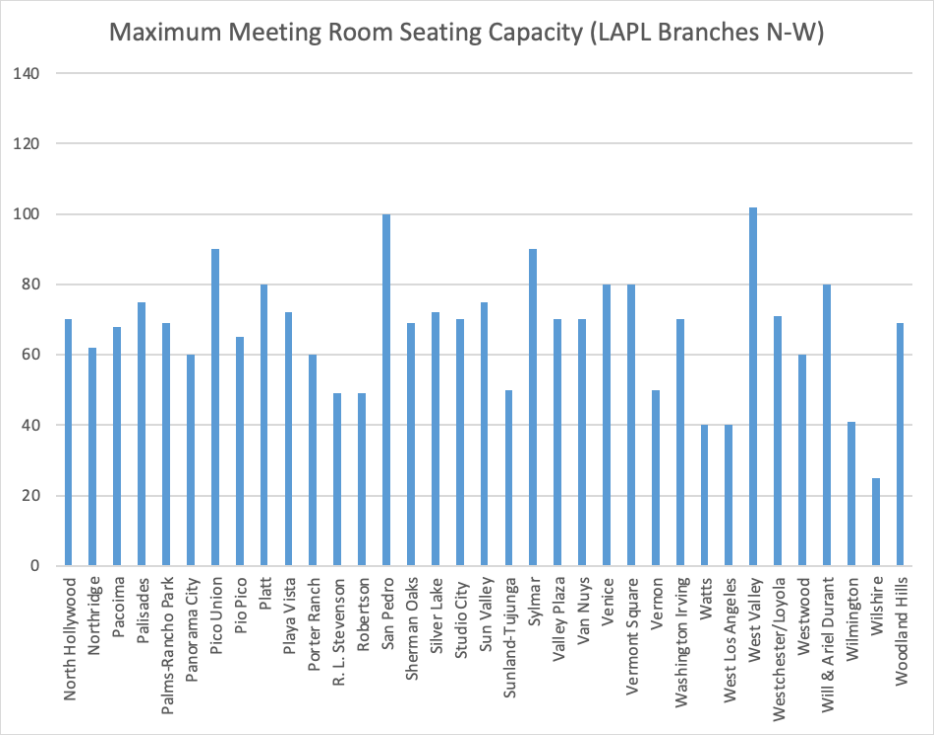
From an interview with the Emergency Management department, our team learned about the processes involved in a cooling center activation, which is when an extreme heat day or period is occurring, and RAP opens specifically designated sites to serve as cooling centers. Cooling Center Services are deployed using an emergency management structure. This process begins with emergency management in contact with other city agencies, and looking at adverse weather calls. Based on protocols and standards within RAP, they determine when and how to activate, based on certain thresholds, and coordination with safety officers and council districts, which then determines the number of cooling centers to be opened during adverse weather. From there, deployment of staff and resources to these sites are set, including water, signage, staffing and parameters around programming. Recreation and Parks also have their own procedures for tracking and reporting to ensure cooling sites are in locations most utilized.

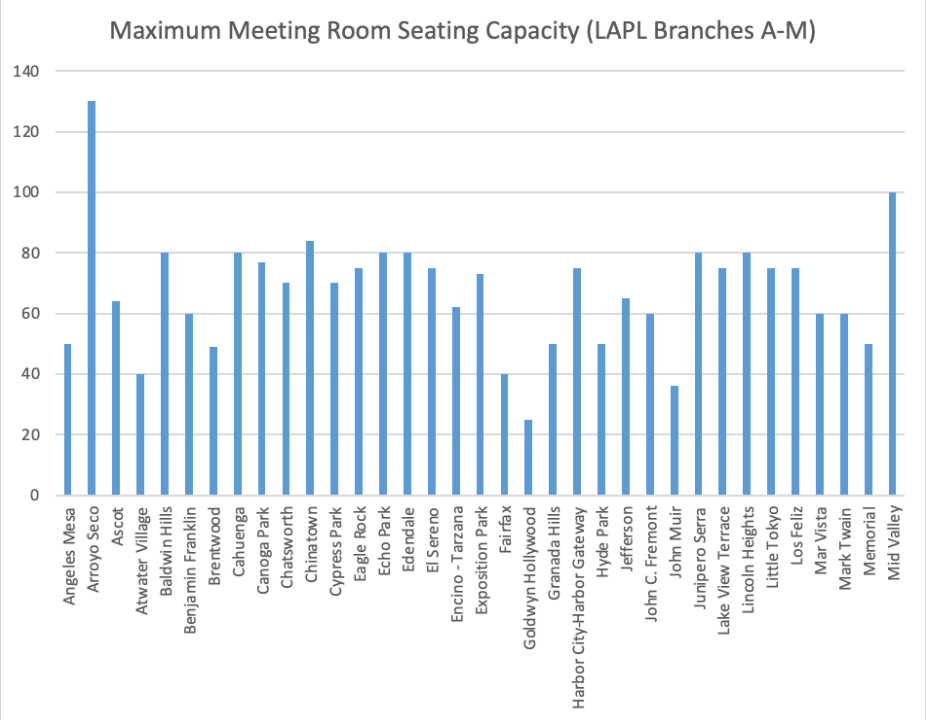
Recreation and Parks - Outreach & Programming

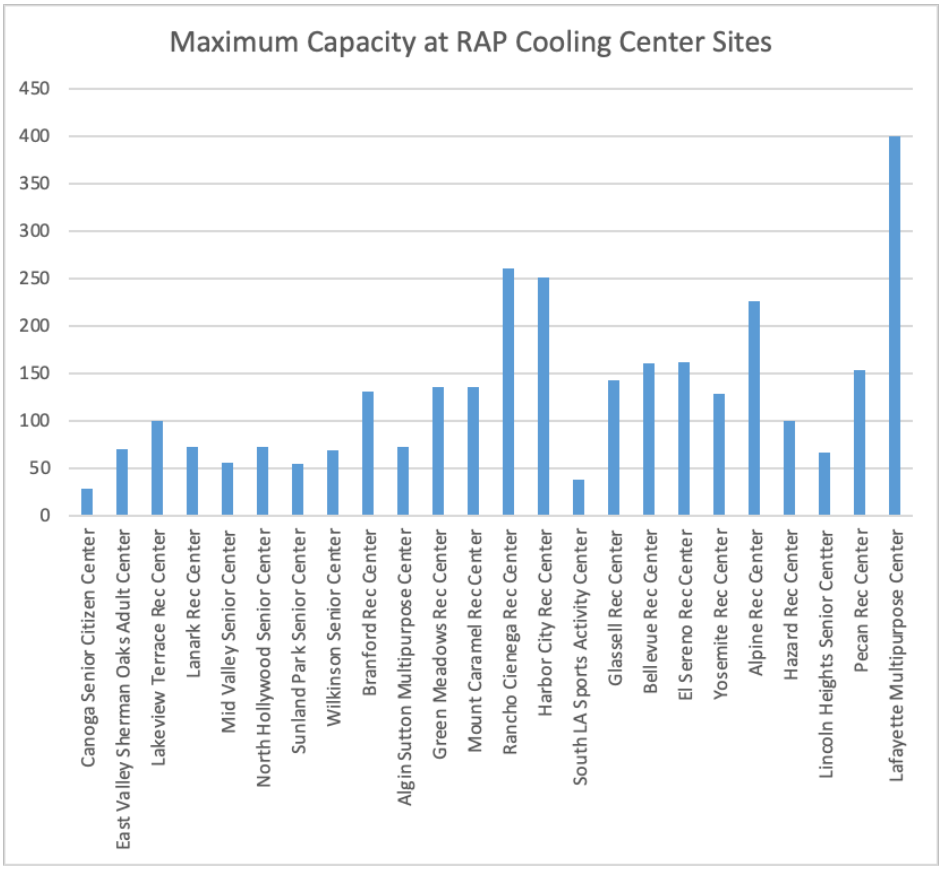
One of the most important aspects that differentiates RAP cooling center activation sites from other cooling center sites is that recreation and park facilities all have their own unique daily programming, many of which involve children. This factor heavily influences how cooling sites are planned and opened, as there are instances where children cannot be exposed with the general public for safety and liability reasons. For this reason, opening doors to the general public as a cooling site is complex, and involves multiple city agencies in order to determine which sites can be opened as cooling centers during adverse weather. Recreation and Park's strategy aims to keep programming in place, and to focus on expansion of hours and resources, rather than displacing programming or closing resources. In discussion about outreach methods for cooling centers, RAP informed us that they have a Public Relations Officer who works with them on press releases, websites, social media and print, which is under the emergency management structure. Although each cooling site has unique programming, all sites receive the same information and outreach tools are standardized across each site.

A site staff member we interviewed who works at an augmented RAP site and has worked at the site during a heat wave period indicated that procedures related to extreme heat are discussed on a monthly basis. They also discussed how additional resources such as solar panels and backup power are extremely useful to the local community as many residents in the community do not have access to AC in their homes. They discussed how additional resources can be helpful beyond heatwaves and used during other emergency and natural disaster events such as earthquakes. The site staff member indicated that during cooling center activations, demographics of visitors tends to shift to include more unhoused and elderly people. Despite this increase, they expressed how members of those communities often face the most barriers in accessing the site, due to transportation and safety issues. The site staff member said that they have partnerships with programs such as GRYD, the Mayor's Office of Gang Reduction and Youth Development program, that includes prevention and intervention workers that walk around sites to ensure everyone is safe.

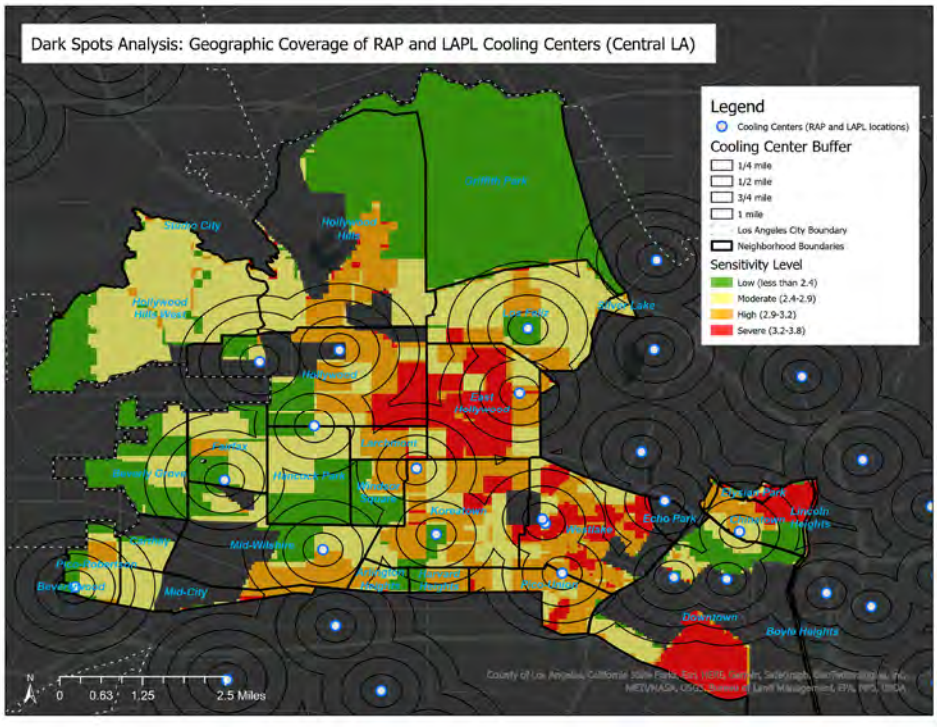
Appendix E: Supplemental Charts on Cooling Center Facilities

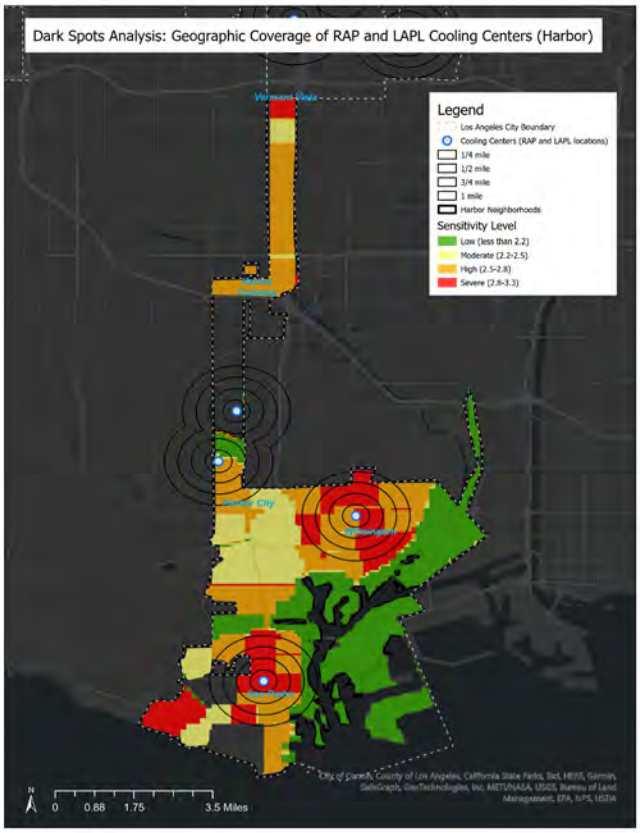


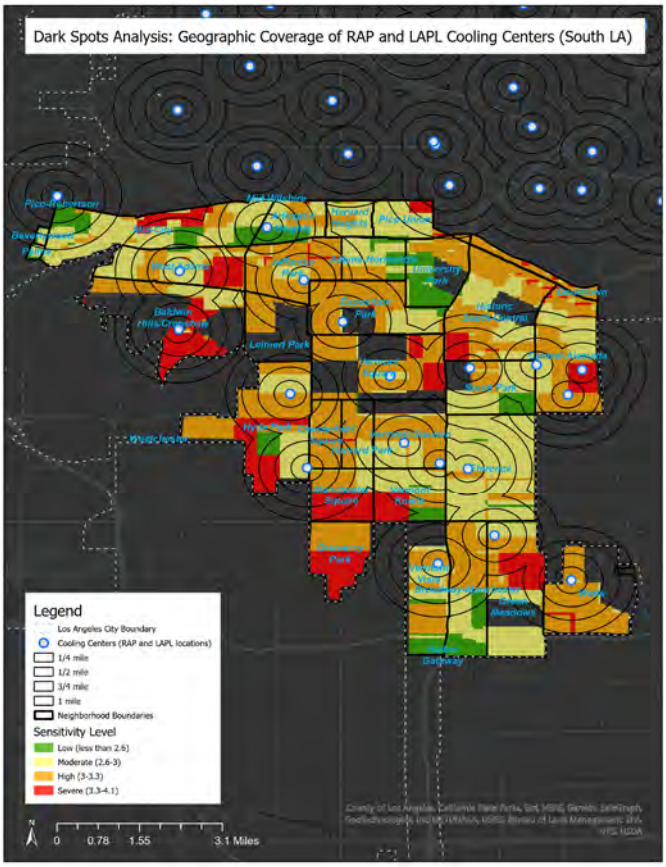


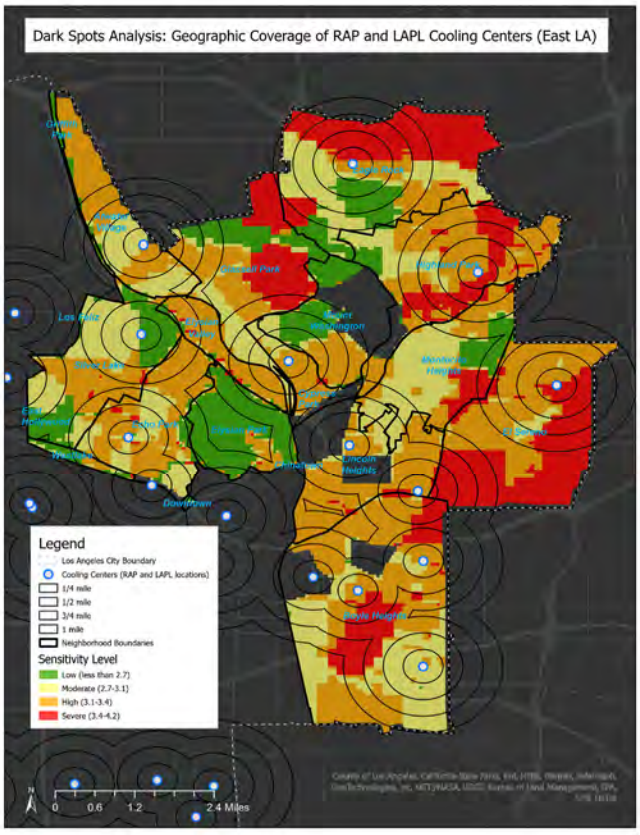


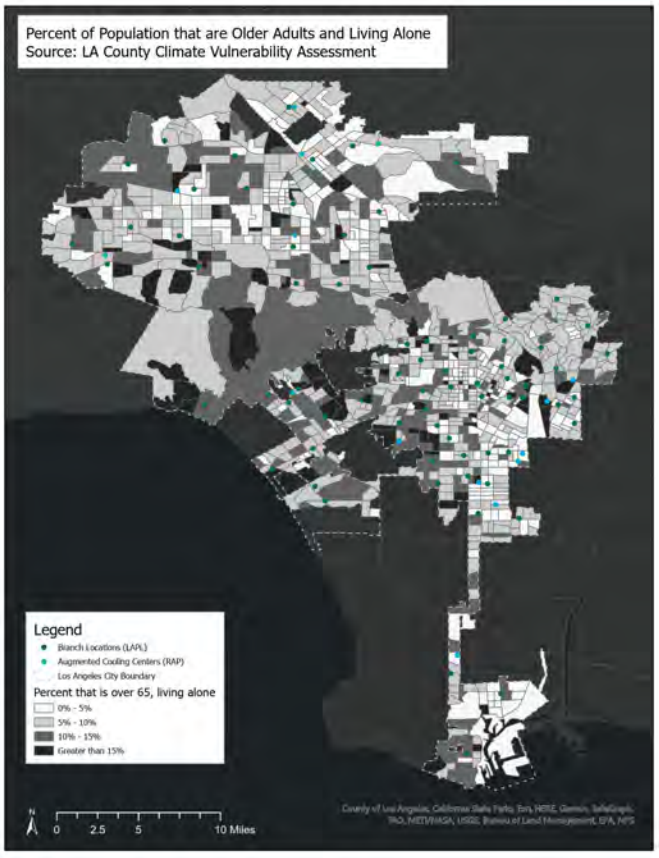
Appendix F: Dark Spots Analysis Maps

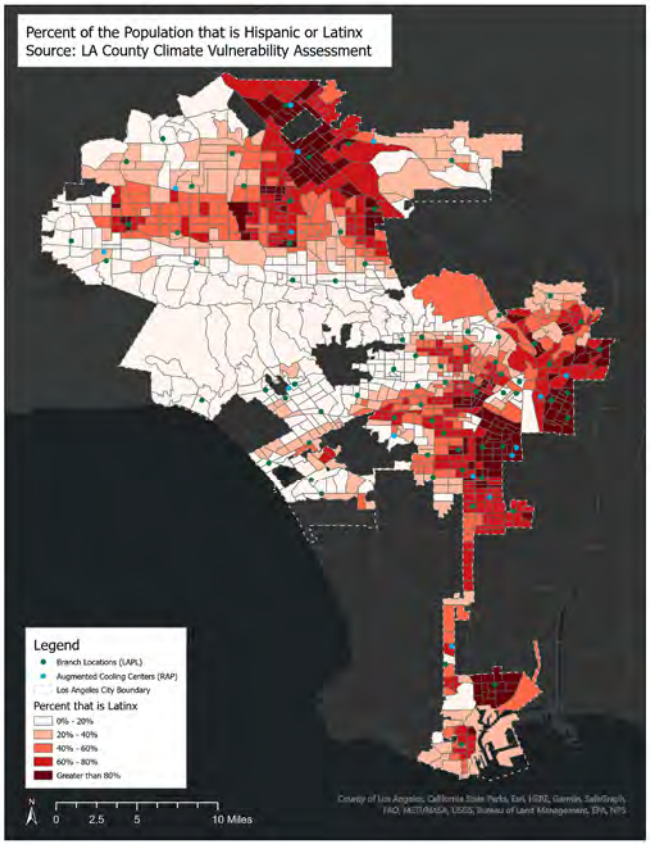


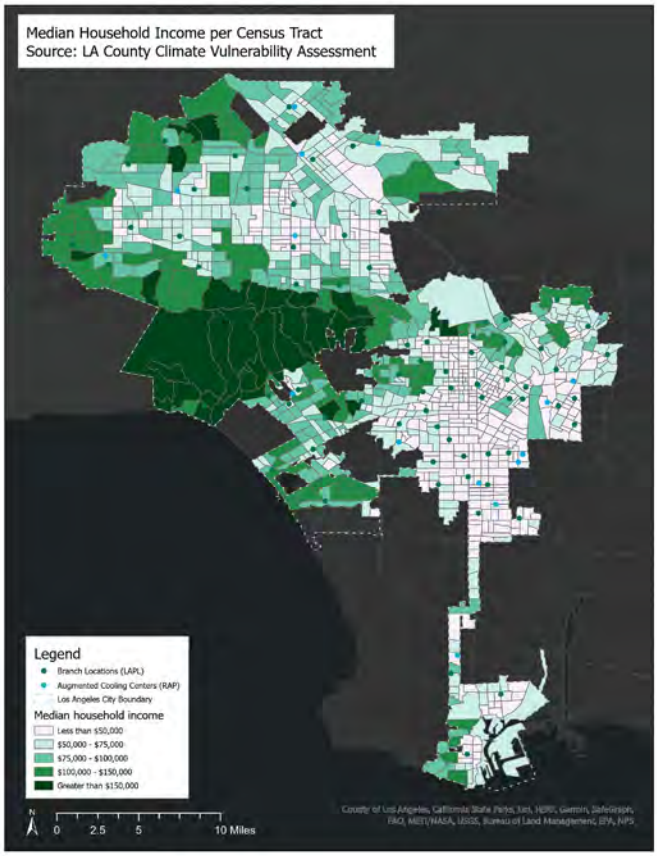

Dark Spots Analysis: Geographic Coverage of RAP and LAPL Cooling Centers (Harbor)
Legend
Los Angeles City Boundary
Cooling Centers (RAP and LAPL locations)
1/4 mile
1/2 mile
3/4 mile
1 mile
Harbor Neighborhoods
Sensitivity Level
Low (less than 2.2)
Moderate (2.2-2.5)
High (2.5-2.8)
Severe (2.8-3.3)
0 0.88 1.75 3.5 Miles


Dark Spots Analysis: Geographic Coverage of RAP and LAPL Cooling Centers (South LA)
Legend
Los Angeles City Boundary
Cooling Centers (RAP and LAPL locations)
1/4 mile
1/2 mile
3/4 mile
1 mile
Neighborhood Boundaries
Sensitivity Level
Low (less than 2.6)
Moderate (2.6-3)
High (3-3.3)
Severe (3.3-4.1)
0 0.78 1.55 3.1 Miles


Dark Spots Analysis: Geographic Coverage of RAP and LAPL Cooling Centers (East LA)
Legend
Los Angeles City Boundary
Cooling Centers (RAP and LAPL locations)
1/4 mile
1/2 mile
3/4 mile
1 mile
Neighborhood Boundaries
Sensitivity Level
Low (less than 2.7)
Moderate (2.7-3.1)
High (3.1-3.4)
Severe (3.4-4.2)
0 0.6 1.2 2.4 Miles


Percent of Population that are Older Adults and Living Alone
Source: LA County Climate Vulnerability Assessment
Legend
Branch Locations (LAPL)
Augmented Cooling Centers (RAP)
Los Angeles City Boundary
Percent that is over 65, living alone
0% - 5%
5% - 10%
10% - 15%
Greater than 15%
0 2.5 5 10 Miles


Percent of the Population that is Hispanic or Latinx
Source: LA County Climate Vulnerability Assessment
Legend
Branch Locations (LAPL)
Augmented Cooling Centers (RAP)
Los Angeles City Boundary
Percent that is Latinx
0% - 20%
20% - 40%
40% - 60%
60% - 80%
Greater than 80%
N
0 2.5 5 10 Miles


Median Household Income per Census Tract
Source: LA County Climate Vulnerability Assessment
Legend
Branch Locations (LAPL)
Augmented Cooling Centers (RAP)
Los Angeles City Boundary
Median household income
Less than $50,000
$50,000 - $75,000
$75,000 - $100,000
$100,000 - $150,000
Greater than $150,000
N
0 2.5 5 10 Miles