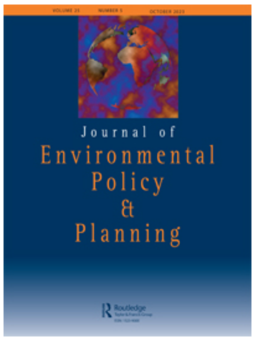

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Urban heat governance: examining the role of urban planning

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ABSTRACT

Heat is an increasing climate risk for cities due to climate change and the urban heat island effect. Extreme heat has inequitable impacts across social, economic, and urban environmental systems. Despite increasing awareness of heat risk, the planning and governance structures for mitigating and managing heat are less understood than those for other climate risks. We studied five large, climatically-diverse U.S. cities to better understand urban heat governance with a focus on the field of urban planning. We first conducted a plan evaluation of these cities' comprehensive, climate action, and hazard mitigation plans ($n = 14$) and then interviewed urban planners, resilience professionals, hazard mitigation planners, emergency managers, and public health professionals ($n = 22$). We found that aspects of heat planning occur across a variety of municipal plans but only a small number of strategies were explicitly framed in terms of heat, suggesting an opportunity to better connect heat with other policy goals. Urban planners tended to play a backseat role relative to other professions, despite the field's importance for reducing heat-related inequity. Better understanding the role of urban planning within broader governance structures can help policymakers to best engage in heat mitigation and management.

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Extreme heat; heat planning; heat governance; climate change; urban heat; heat resilience

1. Introduction

Heat is the deadliest weather-related hazard in the United States (U.S.) (National Weather Service, 2018). Many heat-related deaths are preventable through urban planning and design, and through targeted risk communication (Hajat & Kosatky, 2010). In a survey of U.S. planners, 84% reported their community had already been impacted by extreme heat, with most reported impacts including energy and water use, vegetation and wildlife, public health, and quality of life (Meerow & Keith, 2021). Addressing the impacts of extreme heat will require a greater focus on heat governance, which has been defined as 'the actors, strategies, processes and institutions that mitigate and manage' heat hazards (Keith et al., 2021, p. 30). Advancing urban heat governance will require interdisciplinary approaches involving urban planners, emergency managers, and public health practitioners and integration into comprehensive plans, hazard mitigation plans, sustainability plans, heat action plans, and other policy documents (Berke et al., 2015; Keith et al., 2021). This also will require substantially greater coordination that includes both short- and long-term approaches to mitigating and managing urban heat (Keith et al., 2020).

Urban planners increasingly understand the important role of the discipline in addressing heat in their communities (Keith & Meerow, 2022). Recent studies demonstrate disparities in heat vulnerability, connections between urban heat and other environmental outcomes, and the effects of planning interventions on urban heat (Gabbe et al., 2021; Kim et al., 2020; Stone et al., 2023; Wilson, 2020). Improved interdisciplinary cooperation and action require a better understanding of urban heat planning and governance, our knowledge of which remains limited (Keith et al., 2021).

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1.1. Impacts of urban heat

Extreme heat is an increasing climate risk in cities due to climate change and the urban heat island (UHI) effect. Climate change has increased the frequency, intensity, and duration of extreme heat events such as heat waves and increased average temperature, leading to more chronic heat risk (IPCC, 2021). Global temperature has increased 2°F (1.1°C) since the industrial era (1850–1900) and will reach or surpass 2.7°F (1.5°C) of warming by 2050 with further additional warming likely unless greenhouse gas emissions are aggressively mitigated (IPCC, 2021). In addition to climate change, the planning and design of urban areas often lead them to be hotter than surrounding rural and natural areas due to the UHI effect (Oke, 1973). The UHI effect is exacerbated through land cover change and vegetation loss; the use of heat-trapping materials in the built environment; and waste heat emissions from sources like buildings and vehicles (Stone & Rodgers, 2001). The UHI effect can cause urban temperatures to be as much as 7.2°F (4°C) hotter in the day and 4.5°F (2.5°C) hotter at night compared to the surrounding natural areas (Hibbard et al., 2017). Globally, urban exposure to extreme heat increased 200% from 1983 to 2016 due to the combination of climate change and the UHI effect, affecting 1.7 billion people (Tuholske et al., 2021).

Heat and its impacts are not evenly distributed across urban areas. Historical racist land use practices have led formerly redlined neighborhoods to be hotter than their wealthier and whiter counterparts due to targeted disinvestment (Wilson, 2020). Across the U.S., land surface temperatures of formerly redlined neighborhoods are, on average, 4.7°F (2.6°C) hotter than non-redlined neighborhoods, reaching as much as 12.6°F (7°C) in some instances (Hoffman et al., 2020). Income is also a factor; on both extreme heat days and average summer days, the poorest 10% of U.S. Southwestern city neighborhoods were 2.2°C (4°F) hotter than the wealthiest 10% of neighborhoods (Dialesandro et al., 2021). In addition to spatial differences in heat severity, factors such as access to healthcare (Wondmagegn et al., 2019), safe and reliable transportation (Karner et al., 2015), quality housing (Gabbe & Pierce, 2020; Gabbe et al., 2022), and access and reliability to energy (Brown et al., 2020) also lead to systemic heat inequities. On a global scale, lower income populations already face 40% more exposure to extreme heat events than their wealthier counterparts and by 2100, will face 23 more days of extreme heat events per year (Alizadeh et al., 2022).

1.2. Urban heat planning and governance

Heat-related research is growing, but most published papers focus on mapping and modeling heat, while only 6% focus on planning processes and governance (Keith et al., 2020). In Turek-Hankins et al. (2021) review of heat adaptation actions, efforts to address heat were incrementally occurring across 98 nations. Barnes and Dow (2022) found that while heat was included as a significant hazard in Charleston's All Hazards Vulnerability Assessment, it had no group assigned to lead or coordinate efforts, resulting in the city continuing to prioritize efforts on flood hazards instead.

Communities are utilizing two broad categories of strategies to address heat: heat mitigation and heat management (Keith et al., 2020; Meerow & Keith, 2021). Heat mitigation strategies reduce heat in the built environment such as overall land use changes, neighborhood and site-scale urban design, urban greening, and waste heat reduction (Meerow & Keith, 2021). Heat management strategies address both chronic heat risk and extreme heat events such as emergency preparedness, public health activities, reduction of personal heat exposure, and energy accessibility, affordability and reliability (Meerow & Keith, 2021). Heat mitigation is largely the domain of planning and design disciplines, while heat management has been the focus of public health and emergency management disciplines (Keith et al., 2020). Although several U.S. communities have appointed a chief heat officer or similar position, including Miami-Dade County (FL) and the City of Phoenix, AZ in 2021 (Keith et al., 2021), followed by the City of Los Angeles (CA) in 2022 (City of Los Angeles, 2022), nearly all other U.S. communities do not have a dedicated role for heat governance at the time of this publication.

Most U.S. planners surveyed by Meerow and Keith (2021) were at least somewhat concerned about extreme heat and many U.S. cities have already adopted heat mitigation and management strategies (Gabbe et al., 2021; Meerow & Keith, 2021; Turner et al., 2022). These planning strategies have been included in a variety of plan types, including sustainability, climate action, or resilience plans; comprehensive plans; emergency response plans; and hazard mitigation plans (Gabbe et al., 2021; Meerow & Keith, 2021; Turner et al., 2022). Additionally, some communities are developing heat action plans, a dedicated plan that incorporates both heat mitigation and management (Kotharkar & Ghosh, 2022).

The comprehensive plan is the primary policy document within the urban planning profession and can affect local outcomes depending on certain circumstances. The comprehensive plan is part of a network of plans that also includes those dedicated to specific areas or topics (Berke et al., 2015; Kelly, 2012). This network of plans influences the form of the built environment, and the integration of these plans can increase or decrease resilience to climate risks such as extreme heat (Berke et al., 2015; Berke et al., 2019; Yu et al., 2020). Additionally, engaging local community members in comprehensive planning and other planning processes can improve decision-making for risks such as extreme heat (Corburn, 2003).

However, cities' approaches to heat have been inconsistent, and urban planners face considerable barriers to heat mitigation and management policies and strategies. While some strategies, such as urban forestry, were popular among municipal governments, actual heat-related regulations and staff were uncommon, illustrating 'a lack of regulatory teeth in heat planning' (Meerow & Keith, 2021, p. 9). Some of the largest barriers to municipal heat planning included funding, time, staff resources, higher priority issues, leadership, and public support, among others (Meerow & Keith, 2021). California cities that adopted urban heat island policies tended to have larger populations, hotter temperatures, stronger local leadership support for addressing climate change, larger shares of Democratic voters, smaller shares of Hispanic residents, and an environmental justice plan (Gabbe et al., 2021).

Despite increasing heat risk in cities due to climate change and the UHI effect, relatively few studies have explored heat policy, planning, and governance, compared with the focus urban heat modeling and mapping (Keith et al., 2020). To date, no studies have utilized plan quality evaluation and interviews together, or used plan quality evaluation to identify whether strategies are explicitly connected to heat. To help improve the understanding of urban heat governance, and the role of urban planners, this paper answers two research questions: How are large U.S. cities engaged in urban heat governance? How do urban planning and other disciplines approach and coordinate mitigating and managing urban heat? We answer these questions using plan evaluation and expert interviews in five large U.S. cities that represent a range of climate regions.

2. Data and methods

2.1. Case study selection

We document and assess the current state of emergent urban heat planning and governance in the U.S., through five case study communities: Baltimore, MD; Detroit, MI; Houston, TX; Seattle, WA; and Tucson, AZ (Table 1). We selected these communities in collaboration with the U.S. National Oceanic and Atmospheric Administration (NOAA) Climate Program Office as communities they had previously engaged with on urban heat planning and governance. Each city had either participated in the NOAA heat mapping campaign (NIHHIS, 2023) or had a locally developed urban heat island map (PAG, 2023). The five cities also represent five of the National Climate Assessment regions and a range of geographic and climatic conditions. All

Table 1. Case study characteristics.

City	Population (2019)	Avg daily max temp (current)	Avg daily max temp (2100 high emissions scenario)	Days w/ max > 100°F (current)	Days w/ max > 100°F (2100 high emissions scenario)
Baltimore, MD	2.32M	69°F (20.6°C)	77°F (25°C)	5 days	42 days
Detroit, MI	3.54M	62°F (16.7°C)	70°F (21.1°C)	1 day	23 day
Tucson, AZ	0.98M	85°F (29.4°C)	93°F (33.9°C)	75 days	140 days
Houston, TX	6.37M	81°F (27.2°C)	88°F (31.1°C)	5 days	70 days
Seattle, WA	3.43M	57°F (13.9°C)	64°F (17.8°C)	0 day	2 days

Sources: U.S. census bureau; U.S. climate resilience toolkit; climate explorer.

of the cities used National Weather Service heat warnings and two had additional heat warning systems (i.e. Baltimore's Code Red, Houston's Emergency Heat Plan).[1]

2.2. Plan evaluation

Our plan evaluation focused on heat-related plan content for each community. We analyzed the five types of plans that Lyles et al. (2018) categorized as 'primary adaptation plans': single-impact plans, multi-hazard plans, climate adaptation-only plans, climate action plans, and comprehensive plans. None of the communities had single-impact plans (e.g. heat action plans) or climate adaptation-only plans, so we focused on three types of plans that had been commonly adopted at the time of data collection (2020): (1) local hazard mitigation plans, which are an eligibility requirement for funds from the Federal Emergency Management Agency (FEMA); (2) climate action plans, which may take a variety of forms; and (3) comprehensive plans, which cities may also refer to as general or master plans. We reviewed 14 plans in total because all five cities had these three plan types, except Tucson, which had a climate action plan under development and thus was not analyzed (Appendix A).

We evaluated the communities' plans using predetermined criteria rooted in past studies and organized into established categories. Our criteria were informed by Gabbe et al.'s (2021) plan evaluation, Meerow and Keith's (2021) survey of planners, and heat mitigation and management strategies from Keith et al.'s (2020) review article on heat planning. We do not evaluate these criteria or assess their appropriateness in different urban or climatic contexts. We divided these 34 heat-related criteria into four main categories guided by Berke and Godschalk (2009): 7 criteria on 'issue identification, fact base and goals'; 17 criteria on 'heat mitigation'; 7 criteria on 'heat management'; and 3 criteria on 'implementation' (see Appendix B). Some of the 34 criteria were directly related to heat while others were more general in nature. Fifteen of the criteria directly pertained to heat (e.g. 'urban heat island mapping', 'heat-specific funding') and we assigned each an indicator variable. Nineteen of the criteria were more general (e.g. 'urban forestry', 'land conservation'), and in evaluating these we created two separate indicator variables: (1) whether the criterion was mentioned at all, and (2) whether the criterion was mentioned explicitly in the context of heat. Thus, we had 53 criteria in total, including those with the two parts mentioned above.

Two coders independently reviewed all 14 plans in terms of the 53 criteria. The coders assigned an indicator variable reflecting whether the measure was present in the plan and added additional fields reflecting the page number of each occurrence and relevant quotes. Their coding results were compared and reconciled and were in agreement 89% of the time. We calculated Krippendorf's Alpha, the most widely used measure of intercoder reliability (Stevens et al., 2014). The Krippendorf's Alpha value of 0.73 indicates satisfactory intercoder reliability. We then created a final reconciled version of the dataset by reviewing the coders' notes, reading the plan documents, and discussing the differences with the coders.

2.3. Interviews

We conducted 22 semi-structured interviews with up to five local government staff or policymakers in each community, including urban planners, hazard mitigation planners, resilience professionals, emergency managers, and public health practitioners (Table 2). Specific job titles varied by community, so we classified interviewees into five categories based on their key functions: urban planners, resilience professionals, hazard mitigation planners, emergency managers, and public health practitioners. Urban planners worked with local policies and were involved in long-term planning for their community and its built environment. Resilience professionals worked on climate initiatives and served a coordination role for their community under a variety of titles such as 'chief resilience officer', 'sustainability director,' and 'sustainability coordinator.' Hazard mitigation planners were directly involved with their community's Federal Emergency Management Agency (FEMA) hazard mitigation planning and grant implementation efforts. Emergency managers were focused on preparing for and executing safety procedures during extreme heat events. Public health practitioners developed programs and initiatives focused on residents' health and well-being.

Table 2. Interviewees by city and discipline.

	Primary Adaptation Planning Disciplines			Other Related Disciplines		
	Urban Planners	Resilience Professionals	Hazard Mitigation Planners	Emergency Managers	Public Health Practitioners	Total
Baltimore, MD	1	1	1	1	0	**4**
Detroit, MI	1	1	0	1	0	**3**
Houston, TX	1	1	1	1	1	**5**
Seattle, WA	1	1	1	1	1	**5**
Tucson, AZ	1	1	1	1	1	**5**

All interviewees were recruited through email. All urban planners and resilience professionals were employed by a city government, while hazard mitigation planners, emergency managers, and public health practitioners were employed by either city or county governments, depending on the community. Due to COVID-19 pandemic response efforts at the time of the study, Baltimore did not have a public health practitioner available to participate and Detroit did not have a hazard mitigation planner or public health practitioner available to participate. In all other cases, the participant that we recruited by email was interviewed. The results and discussion note the number of participants by discipline from each city.

We asked participants ten questions about local plans, heat mitigation and management strategies, information resources, cross-department collaboration, partnerships with external stakeholders, and the barriers and opportunities to addressing heat (Appendix C). The interviews lasted approximately 30–45 minutes and were conducted via Zoom, recorded, transcribed, and imported into MaxQDA for analysis.

We generated a codebook in MaxQDA software based on our initial scoping research and interview question topics. We iteratively modified the codebook throughout the analysis to include codes not originally included, such as more-specific heat management strategies (e.g. use of air conditioning as a strategy), collaborators (e.g. medical facilities), and challenges (e.g. framing heat as a hazard).

In addition to capturing notable quotes, we compiled the coded interview data from MaxQDA into quantified responses. Our descriptive statistics include total results by code and then a percentage measure by discipline (the numerator was affirmative responses for the code item and the denominator was the total interviewees from that discipline).

2.4 Limitations

There are several limitations to our findings and analysis. First, due to the COVID-19 pandemic response during the study period, three relevant interviewees were unavailable to participate. Second, because our analysis focused on adaptation plans relevant to urban planning, we did not include other plans that may also have insights, including emergency management and public health plans. Finally, the cities selected are all larger cities and further research is needed to establish the generalizability of these findings across city sizes, climate regions, and previous levels of engagement on heat issues. Additional research is also needed to understand how urban heat planning is developing in the handful of communities with dedicated heat officers at one end of the spectrum, and the many smaller towns and cities with limited resources at the other end.

3. Results

The results from the five cities are presented first from the plan evaluation, followed by the interviews.

3.1. Plan evaluation results

Most city plans identified heat as an issue, included facts about heat and vulnerability, and/or proposed heat-related goals (Table 3). Heat was identified as an issue in every hazard mitigation plan and nearly every

Table 3. Summary of plan evaluation results.

Theme category	Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Plans discussed	Climate action plan, resilience, or adaptation plan	2	3	3	6	1	15
	Hazard mitigation plan	0	4	4	4	2	14
	Public health plan	0	3	2	2	3	10
	Emergency management plan	0	2	3	2	1	8
	Comprehensive plan	2	0	0	2	0	4
Heat mitigation strategies discussed	Urban forestry	3	4	3	6	1	17
	Green stormwater infrastructure	3	1	2	6	1	13
	Building energy efficiency	4	1	3	3	1	12
	Parks and vegetated open space	2	3	2	3	1	11
	Cool or reflective surfaces	2	1	0	3	1	7
	Land use and urban design	2	1	0	2	1	6
	Built shade structures	1	1	1	1	0	4
	Green roofs and walls	2	0	1	1	0	4
	Land conservation	0	0	0	0	0	0
Heat management strategies discussed	Cooling centers or resilience hubs	3	4	5	6	3	21
	Information or awareness campaigns	2	4	2	5	3	16
	Air conditioning	3	3	1	4	1	12
	Energy assistance programs	1	2	3	2	1	9
	Weatherization assistance programs	1	2	1	4	0	8
	Services for people experiencing homelessness	0	2	3	1	1	7
	Heat warning or alert systems	1	1	0	1	1	4
	Regulations for outdoor work or recreation	0	1	0	0	1	2
Collaborators discussed	Public health department	4	4	5	6	3	22
	Non-governmental organizations (non-profits)	3	3	5	6	3	20
	Emergency management department	2	4	5	3	3	17
	Sustainability or resiliency department	3	3	4	4	2	16
	Utility company	4	3	2	3	1	13
	Planning department	3	1	2	1	1	8
	Grassroots organizations	0	1	0	1	1	3

Note: Additional strategies and detail are shown in Appendix E.

comprehensive plan and climate action plan. Local plans commonly included climate projections but only four plans included climate projections specifically pertaining to future temperature increases. Climate projections were used in all climate action plans, but less so in comprehensive plans and hazard mitigation plans. Data on vulnerable populations generally, though not necessarily related to heat, were less common in comprehensive plans than the other plan types. Meanwhile, only four plans specifically referenced heat in relation to vulnerable populations. Maps of the UHI effect or urban forestry were rarely included across cities and plan types. Climate action plans most broadly included the issue identification, fact base, and goals criteria, and hazard mitigation plans incorporated many of these criteria.

A handful of heat mitigation strategies were common across cities and plan types. The strategies that plans included were parks, land conservation, waste heat reduction from transportation, urban forestry, water features, and waste heat reduction from buildings. Some of these were commonly mentioned specifically in the context of heat, particularly parks and urban forestry. Others were mentioned generally, though rarely or never in the context of heat, including waste heat reduction from transportation, water features, land conservation, and waste heat reduction from buildings.

Heat mitigation strategies were more widely addressed in comprehensive plans and climate action plans than in hazard mitigation plans. For example, every comprehensive plan addressed parks, land conservation, waste heat from transportation, urban forestry, and urban density. Again, these were not always mentioned specifically in the context of heat. Climate action plans incorporated the broadest range of heat mitigation strategies; about two-thirds of our criteria were included in at least one climate action plan.

Heat management strategies were less prevalent in the plans than heat mitigation strategies. The most common heat management strategies were cooling centers, education about the effects of heat, and weatherization programs. These strategies, however, were not evenly distributed across plans. Rather, they were more likely to be present in climate action plans and hazard mitigation plans than in comprehensive plans. A handful of strategies were included in two or fewer plans, including regulations for outdoor workers, utility assistance specifically referencing heat, heat response plans, heat-specific weatherization assistance, and early warning systems.

Cities' heat-specific implementation activities – including responsibility, coordination, and funding – were not specified in most local plans. No comprehensive plan evaluated included any implementation criteria that were heat-specific. Hazard mitigation plans commonly identified responsible agency(s) for heat, but otherwise, this was observed in only one city's climate action plan. Coordination was mentioned in several climate action plans and hazard mitigation plans, while funding was only mentioned in two hazard mitigation plans.

3.2. Interview results

The 22 interview participants indicated that a variety of plans were used in heat mitigation and management, including hazard mitigation plans, public health plans, climate action plans, emergency management plans, and comprehensive plans (Table 4). While no single plan was discussed by all participants, participants most frequently mentioned their city's climate action plans in relation to heat. The least two commonly discussed plans were emergency management plans and comprehensive plans. Only four participants mentioned comprehensive plans in relation to heat, and these were two planners and two resilience professionals. Various participants also mentioned a variety of other plans, such as city parks plans and green stormwater infrastructure plans.

The most common heat information source participants reported using was UHI maps. Participants referred to their community's participation in the NIHHIS Heat Mapping Campaign or the self-developed UHI map in the Tucson region. UHI maps were often discussed in terms of helping determine where to target heat mitigation efforts. One planning participant stated, 'We have a [UHI] map that shows where the hottest and coolest areas are. We pair that information with a map showing tree canopy and a prioritized list of green infrastructure projects or LID [low impact development] projects for where we could get the greatest benefit for building a project.'

Emergency management and public health participants commonly discussed relying on weather forecasts for decision-making. One emergency management participant emphasized the importance of forecasts, 'We

Table 4. Summary of interview results.

Category	Criteria	Comprehensive Plan (n=5)	Climate Action Plan (n=4)	Hazard Mitigation Plan (n=5)	Total (n=14)
Issue identification, fact base, and goals	Identifies extreme heat as issue	3	3	5	11
	Climate projections	2	4	1	7
	Vulnerability data	1	3	3	7
	Identifies heat equity as an issue	0	2	4	6
	Heat-specific goals	2	1	3	6
	Urban heat island mapping	0	2	0	2
	Urban forestry/vegetation mapping	0	1	0	1
Heat mitigation strategies	Parks and vegetated open space	5	3	4	12
	Land conservation	5	3	3	11
	Waste heat reduction (transportation)	5	4	1	10
	Urban forestry	5	3	2	10
	Water features	3	3	4	10
	Waste heat reduction (buildings)	4	4	2	10
	Urban geometry and density	5	2	1	8
	Green stormwater infrastructure	3	3	1	7
	Building envelopes and materials	3	3	1	7
	Weatherization programs	2	4	0	6
	Green roofs and walls	2	3	0	5
Heat management strategies	Cooling centers	0	2	3	5
	Heat education and outreach	1	2	2	5
	Weatherization assistance	1	3	1	5
	Utility assistance	1	2	0	3
Implementation	Heat-specific responsibility	0	1	4	5
	Heat-specific coordination	0	2	2	4
	Heat-specific funding	0	0	2	2

Note: Additional strategies and detail are shown in Appendix E.

use the National Weather Service and defer to them for everything from warnings to heat advisories. They are our biggest resource.'

Almost all participants brought up the topic of heat vulnerability, even without it being specifically asked about. Vulnerability maps or assessments were common information sources discussed by all disciplines and were used by all hazard mitigation planning and all public health interviewees. Many participants discussed using variations of the U.S. CDC's Social Vulnerability Index along with housing and transportation data. A public health participant discussed the importance of vulnerability to know where to focus efforts, 'A lot of people are going to be uncomfortable in the heat while a smaller number are going to be really uncomfortable. From a public health point of view, you want to focus in on who are the ones who are seriously at risk.'

Urban planning and resilience participants were the most consistent in how they discussed heat mitigation strategies, while public health participants spoke the least about heat mitigation overall. The most common heat mitigation strategy discussed across disciplines was urban forestry. A common theme among participants was the public appeal of trees, 'Increasing our tree canopy is popular. People love trees.' In several interviews, it was the sole heat mitigation strategy discussed, 'Focusing on planting trees, that's the priority.' At least half of the participants discussed other common heat mitigation strategies such as green stormwater infrastructure, energy efficiency for buildings, and parks/vegetated open space in cities. Participants less frequently mentioned built shade structures, green roofs/walls, and water features.

Land use and urban design-related heat mitigation strategies were infrequently discussed by participants across disciplines and only by two of the four urban planners. Almost all urban planners reported that land use regulations were not yet being used for heat mitigation. One planner stated, 'Extreme heat has not been an issue that our development regulations have addressed at all.' No participants discussed land conservation outside of urbanized areas as a heat mitigation strategy.

Several heat management strategies were commonly mentioned by interviewees. Almost all interview participants discussed the cooling centers available in their city. Common cooling center locations included libraries, parks, recreation centers, and churches. Many participants discussed uncertainty about the effectiveness of cooling centers as a heat management strategy. One public health participant discussed how cooling centers were frequently empty: 'It's very demoralizing if you activate a cooling site and nobody shows up, and volunteers or employees gave up their weekend with family.' Another public health participant discussed the staffing-related difficulties of operating cooling centers on a longer-term basis. Several participants discussed resilience hubs – centers intended to increase climate resilience along with other community-building goals – as being more useful than cooling centers due to their multiple functions. Informational and heat awareness campaigns were another common heat management strategy acknowledged by over half of the participants, including all hazard mitigation and public health participants. Participants also frequently mentioned providing air conditioning as a heat management strategy.

Participants less frequently discussed heat management strategies such as heat warnings or alert systems, regulations for outdoor work or recreation, services for people experiencing homelessness, weatherization programs, and energy assistance programs. When participants discussed addressing the heat risk of people experiencing homelessness, it was always paired with discussion about the role of social service providers and nonprofit organizations.

All interviewees across disciplines reported collaborating within and across their local governments to address heat, with all participants reporting collaboration with public health departments. Most participants also discussed collaborating with non-governmental organizations to address heat. There was variation in the extent to which representatives of the various disciplines communicated with those in other disciplines and levels of government, such as the hazard mitigation participants collaborating with the highest number of local government departments. The federal government was mentioned more than state governments. Federal government agencies specifically discussed as being important resources included the CDC, EPA, FEMA, and NOAA – particularly the National Weather Service.

Urban planning participants reported collaborating with the fewest disciplines, but uniquely mentioned utilities the most, with all planners discussing their local utility's involvement with home weatherization programs. All public health participants and resilience participants, and almost all hazard mitigation and emergency management participants, reported collaborating with their local university. Universities as important sources of information and collaboration were brought up by at least one participant in each city. The stakeholders who were least discussed for collaboration among all the participants were the planning departments, private medical facilities, and grassroots or community organizations.

Almost all participants agreed that barriers and opportunities present in their city included resources (especially funding), coordination or collaboration, and expertise or more information. In regards to coordination, one resilience participant stated, 'Our city government is pretty siloed and so working cross-departmental is a lift.' Another resilience participant reported, 'There isn't a coherent, uniform voice, or even a hub where all this information lives.' One urban planner explained that, 'We're trying to be more coordinated, but you know in an organization that has more than 10,000 employees and dozens of departments, it's really easy to get siloed.'

Interviewees also reported competing priorities, such as other climate risks, and the difficulty of framing of extreme heat as challenges in their cities. As stated by one planning participant, 'By itself, heat just doesn't garner attention. That's our challenge. You can't get attention to heat without tying it to something else.'

An emergency management participant said, 'I think there's a huge lack of public knowledge on what it even is.' A public health participant pointed out, 'The understanding of extreme heat is a real problem. It's impacting your people and they don't even know it.' Our interviews were conducted in 2020 and 2021, and all hazard mitigation and public health participants mentioned the COVID-19 pandemic as an additional challenge to address heat.

4. Discussion

The five large US cities we studied are engaged in urban heat governance in a variety of ways. Our findings show that these cities are increasingly acknowledging urban heat as a significant concern. They are incorporating strategies to mitigate and manage urban heat in various plans and involving multiple stakeholders for collaborative implementation. However, there are ample opportunities for further progress. These include framing heat in plans using evidence and an equity lens, integrating heat-related strategies across different plan types, and allocating sufficient resources for implementing heat mitigation and management measures.

While each city had unique issues, we generally found that urban planning had a relatively limited role in urban heat governance. This was evident from both the role of urban planning practitioners and the content of the comprehensive plan, which are central to urban planning. Urban planners were commonly disconnected from those actors in urban heat governance roles in public health, emergency management, and sustainability; these disciplines were more actively and directly engaged in urban heat issues. Apart from a handful of heat mitigation strategies, comprehensive plans lagged behind other plans in urban heat framing, heat mitigation, heat management, and implementation.

Our discussion thus focuses on two key topics related to urban planning. We present these topics as opportunities for policymakers and further research. We first explore the urban planning field's leadership opportunity in urban heat governance. We then examine the potentially foundational role of the comprehensive plan in local heat leadership and coordination.

4.1. An opportunity for urban planning leadership in heat governance

While our analysis provides evidence that cities are expanding their climate adaptation planning (Shi et al., 2015), it also demonstrates how urban heat is a critical, yet underdeveloped aspect of local governance (Gabbe et al., 2021; Keith et al., 2021). The content analysis and interviews reveal the lack of a clear 'problem owner' for coordinating the individual disciplinary roles in urban heat governance, which presents an opportunity for urban planners. Urban planning was reported by participants to be the discipline least engaged in urban heat governance, which was surprising given the interdisciplinary nature of urban planning and the myriad of ways that urban planning shapes the built and natural environments.

The interviews and plan analysis results suggest an opportunity for leadership from urban planners in community urban heat governance. While urban planners have been less engaged than other disciplines in heat governance, urban planning interviewees expressed concern with extreme heat and were motivated to address it. This is consistent with survey results showing that most planners are already at least somewhat concerned about heat and have already experienced heat impacts in their communities (Meerow & Keith, 2021). Planners also discussed actively seeking to coordinate across departments and stakeholders within the city government. One collaboration model mentioned by all urban planning interviewees was working with utility companies on home weatherization programs.

Urban planners can expand their roles in heat governance by clearly communicating the existing and future heat risk to the public. Although most plans did reference extreme heat to some extent, most interview participants reported a lack of public awareness about heat as a health risk. While the majority of plans identified heat as an issue, fewer plans identified issues related to heat vulnerability and equity, and the results at least partially depended on communities' past experiences with heat. The lack of heat-related data in plans also indicates an opportunity for planners to coordinate data collection efforts about existing conditions, vulnerabilities, and future climate projections.

Urban planners should engage with grassroots and community organizations, and expand strategies to reverse thermal inequities by race and economic status. Given what we know about thermal inequities experienced by people of color and those with lower incomes (Dialesandro et al., 2021; Mitchell & Chakraborty, 2018), it will be particularly important for planners, emergency managers, and others to collaborate with local groups working on racial and economic justice. Our results, building on past research, indicate that local heat-related efforts are largely focused on a handful of strategies, such as urban forestry and cooling centers, and these were not couched in terms of social justice. If local governments are to reverse thermal inequities, their work must be done in partnership with community organizations and include significant public investments in a broader suite of strategies.

4.2. Strengthening urban heat topics in the comprehensive plan

Planners should ensure that heat-related topics are better incorporated in their community's comprehensive plan. While climate action plans and hazard mitigation plans were referenced in the interviews the most in the context of heat, no single plan stood out in any of the cities as the 'go to' for heat planning. Comprehensive plans certainly did not fulfill this role; half of the planners interviewed did not mention their own comprehensive plan in terms of heat mitigation and management strategies. This is similar to survey results of U.S. planners who reported addressing heat across sustainability, climate action, or resilience plans (36%); comprehensive plans (25%); and hazard mitigation plans (19%) (Meerow & Keith, 2021). Comprehensive plans are also important because they are mandated in many states and are more likely to directly influence the built environment than climate action plans due to their direct use in the land development process (Kelly, 2012).

Urban planners should also incorporate a wider variety of evidence-based cooling strategies for heat mitigation and management goals in their community's comprehensive plans. These strategies are well-suited to comprehensive plans and less likely to be included in other local plans and strategies. Urban greening strategies were the most popular heat mitigation strategy across the cities in our analysis, which is consistent with, and adds detail to, past scholarship on planning for urban heat (Gabbe et al., 2021; Meerow & Keith, 2021; Stone et al., 2023). However, heat mitigation strategies with arguably important heat mitigation benefits, such as land conservation, built shade structures, and site and neighborhood design standards, were rarely identified in existing plans.

Within comprehensive plans, urban planners can also better articulate the co-benefits of heat-related strategies and conversely identify heat health as a co-benefit of many existing planning strategies. This builds on the evidence that while cities have generally engaged in more climate change mitigation than adaptation planning (Wang, 2013; Yeganeh et al., 2020), adaptation planning is more likely when it is connected with local environmental, health, and/or economic co-benefits (Bedsworth & Hanak, 2013). Additionally, heat governance is less established than governance of other climate hazards (Hamstead et al., 2020; Keith et al., 2021; Koop et al., 2017).

5. Conclusion

This study explored the current state of urban heat governance, with a focus on the role of urban planning, through interviews and plan evaluation in five large U.S. cities. In the cities we evaluated, we found that heat planning occurs across a wide variety of community plans, but urban planners have an opportunity to utilize more tools and become leaders in heat governance. While all five communities studied were pursuing both heat mitigation and management activities, only a small number of strategies were explicitly for heat, suggesting that a broader suite of policy tools are not being fully utilized. Urban planners can better address heat in their communities by engaging and leading in urban heat governance efforts and integrating heat mitigation and management goals and strategies into local comprehensive plans.

Note

1. Baltimore's Code Red program is activated by the health commissioner when the heat index is expected to reach or exceed 105°F (Martin, 2016). Houston's Emergency Heat Plan is activated by the city when the head index reaches 108°F for two consecutive days (City of Houston, n.d.). In both Baltimore and Houston, once the plans are activated, additional resources such as cooling centers, transportation to cooling centers, and heat-health messaging are made available.

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Appendices

Appendix A. Plans evaluated

City	Plan Type	Plan Name	Adoption
Baltimore	General Plan	City of Baltimore Comprehensive Master Plan	2006
	Hazard Mitigation Plan	Baltimore County Hazard Mitigation Plan Update	2014
	Climate Action Plan	Baltimore Climate Action Plan	2012
Detroit	General Plan	City of Detroit Master Plan of Policies	2009
	Hazard Mitigation Plan	Detroit, Michigan Hazard Mitigation Plan	2015
	Climate Action Plan	Detroit Climate Action Plan	2017
Houston	General Plan	Plan Houston Final Report	2015
	Hazard Mitigation Plan	City of Houston Hazard Mitigation Plan Update 2018	2018
	Climate Action Plan	Houston Climate Action Plan	2020
Seattle	General Plan	Seattle 2035 Comprehensive Plan	2016
	Hazard Mitigation Plan	City of Seattle 2015–2021 All-Hazards Mitigation Plan	2015
	Climate Action Plan	Seattle Climate Action	2018
Tucson	General Plan	Plan Tucson	2013
	Hazard Mitigation Plan	Pima County Multi-Jurisdictional Hazard Mitigation Plan	2017
	Climate Action Plan	–	–

Note: Tucson was developing its climate action plan at the time of data collection.

Appendix B. Plan evaluation criteria

Category	Criteria	Explicitly heat-related*
Issue identification, fact base, and goals	Identifies extreme heat as issue	✓
	Identifies heat equity as an issue	✓
	Urban heat island mapping	✓
	Climate projections	
	Urban forestry/vegetation mapping	
	Vulnerability data	
	Heat-specific goals	✓
Heat mitigation policies	Urban geometry and density	
	Ventilation corridors	
	Building and street orientation	
	Building massing, shape, and size	
	Built shade structures	✓
	Cool pavements	✓
	Waste heat reduction (transportation)	
	Urban forestry	
	Green roofs and walls	
	Water features	
	Land conservation	
	Parks and vegetated open space in city	
	Green stormwater infrastructure	
	Building envelopes and materials	
	Waste heat reduction (buildings)	
	Weatherization programs	
	Cool roofs and walls	✓
Heat management policies	Cooling centers	✓
	Early warning systems	✓
	Heat response plan	✓
	Heat education and outreach	✓
	Weatherization assistance	
	Utility assistance	
	Heat-safety regulations for outdoor work or recreation	✓
Implementation	Heat-specific coordination	✓
	Heat-specific funding	✓
	Heat-specific responsibility	✓

* For the criteria that are not explicitly heat-related, we analyzed in two ways, dividing in terms of 'any' and 'heat-related' mentions.

Appendix C. Semi-structured interview questions

1. Which governments, institutions, or other organizations in your community address extreme heat risk?
2. Who are the specific stakeholders you work with in your community to address extreme heat risk?
3. Which plans in your community address extreme heat risk?
4. What specific risk management strategies for extreme heat is your community using or planning to use?
5. What specific planning and design of the built environment strategies to mitigate extreme heat is your community using or planning to use?
6. What sources of extreme heat information have you used?
7. What are your most pressing extreme heat information needs?
8. What are the barriers to addressing extreme heat in your community?
9. What would best help your community advance efforts to address extreme heat?
10. Is there anything else you would like to share about extreme heat in your community?

Appendix D. Detailed plan evaluation results

Table D1. Plan evaluation: Issue identification, fact base, and goals criteria.

Criteria	Comprehensive Plan (n=5)	Climate Action Plan (n=4)	Hazard Mitigation Plan (n=5)	Total (n=14)
Identifies extreme heat as issue	3	3	5	11
Climate projections (any)	2	4	1	7
Vulnerability data (any)	1	3	3	7
Identifies heat equity as an issue	0	2	4	6
Heat-specific goals	2	1	3	6
Climate projections (heat-related)	1	3	0	4
Vulnerability data (heat-related)	0	2	2	4
Urban heat island mapping	0	2	0	2
Urban forestry/vegetation mapping (any)	0	1	0	1
Urban forestry/vegetation mapping (heat-related)	0	1	0	1

Table D2. Plan evaluation: Heat mitigation criteria.

Criteria	Comprehensive Plan (n=5)	Climate Action Plan (n=4)	Hazard Mitigation Plan (n=5)	Total (n=14)
Parks and vegetated open space in city (any)	5	3	4	12
Land conservation (any)	5	3	3	11
Waste heat reduction (transportation) (any)	5	4	1	10
Urban forestry (any)	5	3	2	10
Water features (any)	3	3	4	10
Waste heat reduction (buildings) (any)	4	4	2	10
Urban geometry and density (any)	5	2	1	8
Parks and vegetated open space in city (heat-related)	3	3	1	7
Green stormwater infrastructure (any)	3	3	1	7
Building envelopes and materials (any)	3	3	1	7
Urban forestry (heat-related)	3	3	0	6
Weatherization programs (any)	2	4	0	6
Green roofs and walls (any)	2	3	0	5
Building massing, shape, and size (any)	2	2	0	4
Green roofs and walls (heat-related)	0	3	0	3
Green stormwater infrastructure (heat-related)	1	2	0	3
Waste heat reduction (buildings) (heat-related)	1	1	1	3
Cool roofs and walls	0	2	1	3
Land conservation (heat-related)	0	2	0	2
Building envelopes and materials (heat-related)	1	0	1	2
Weatherization programs (heat-related)	0	2	0	2
Urban geometry and density (heat-related)	1	0	0	1
Ventilation corridors (any)	1	0	0	1
Building and street orientation (any)	1	0	0	1
Building massing, shape, and size (heat-related)	0	1	0	1
Ventilation corridors (heat-related)	0	0	0	0
Building and street orientation (heat-related)	0	0	0	0
Built shade structures	0	0	0	0
Cool pavements	0	0	0	0
Waste heat reduction (transportation) (heat-related)	0	0	0	0
Water features (heat-related)	0	0	0	0

Table D3. Plan evaluation: Heat management criteria.

Criteria	Comprehensive Plan (n=5)	Climate Action Plan (n=4)	Hazard Mitigation Plan (n=5)	Total (n=14)
Cooling centers	0	2	3	5
Heat education and outreach	1	2	2	5
Weatherization assistance (any)	1	3	1	5
Utility assistance (any)	1	2	0	3
Early warning systems	0	1	1	2
Weatherization assistance (heat-related)	0	1	1	2
Heat response plan	0	1	0	1
Utility assistance (heat-related)	0	0	0	0
Heat-safety regulations for outdoor work or recreation	0	0	0	0

Appendix E. Detailed interview results

Table E1. Interviews: Plans discussed.

Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Other Plans (e.g., parks and recreation plans, green stormwater infrastructure plans)	4	3	2	5	2	16
Climate action plan, resilience, or adaptation plan	2	3	3	6	1	15
Hazard mitigation plan	0	4	4	4	2	14
Public health plan	0	3	2	2	3	10
Emergency management plan	0	2	3	2	1	8
Comprehensive plan	2	0	0	2	0	4

Table E2. Interviews: Information sources discussed.

Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Urban heat island maps	3	4	3	6	1	17
Vulnerability maps and/or assessments	1	4	1	3	3	12
Current or seasonal weather outlooks	1	2	4	1	3	11
Public health info	1	2	2	1	2	8
Future climate projections	1	2	2	2	1	8
Urban forestry or vegetation maps	1	3	0	2	1	7
Heat Index	0	1	2	1	1	5
Historic climate data	0	0	3	0	0	3
Ambient air temperature maps	0	0	0	0	0	0

Table E3. Interviews: Heat mitigation strategies discussed.

Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Urban forestry	3	4	3	6	1	17
Green stormwater infrastructure	3	1	2	6	1	13
Energy efficiency for buildings	4	1	3	3	1	12
Parks and vegetated open space in city	2	3	2	3	1	11
Cool or reflective surfaces	2	1	0	3	1	7
Land use and urban design	2	1	0	2	1	6
Built shade structures	1	1	1	1	0	4
Green roofs and walls	2	0	1	1	0	4
Water features	1	0	0	0	1	2
Land conservation	0	0	0	0	0	0

Table E4. Interviews: Heat management strategies discussed.

Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Cooling centers or resilience hubs	3	4	5	6	3	21
Information or awareness campaigns	2	4	2	5	3	16
Air conditioning	3	3	1	4	1	12
Energy assistance programs	1	2	3	2	1	9
Weatherization assistance programs	1	2	1	4	0	8
Services for people experiencing homelessness	0	2	3	1	1	7
Heat warning or alert systems	1	1	0	1	1	4
Regulations for outdoor work or recreation	0	1	0	0	1	2

Table E5. Interviews: Collaborators discussed.

Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Local government: Public health department	4	4	5	6	3	22
Non-governmental organizations (non-profits)	3	3	5	6	3	20
Federal government	1	4	4	6	3	18
Local government: Emergency management department	2	4	5	3	3	17
Local government: Sustainability or resiliency department	3	3	4	4	2	16
University	1	3	3	6	3	16
Local government: Parks and recreation department	3	4	3	3	2	15
Private sector	3	4	3	3	2	15
Utility company	4	3	2	3	1	13
State government	0	3	3	3	1	10
Local government: Planning department	3	1	2	1	1	8
Medical facilities	1	1	2	2	1	7
Grassroots organizations	0	1	0	1	1	3

Table E6. Interviews: Opportunities and challenges discussed.

Code	Urban Planners (n=4)	Hazard Mitigation Planners (n=4)	Emergency Managers (n=5)	Resilience Professionals (n=6)	Public Health Practitioners (n=3)	Total (n=22)
Expertise, information, and case studies	4	4	4	6	3	21
Vulnerability	4	4	4	6	2	20
Coordination or collaboration	3	4	4	6	3	20
Financial resources	4	4	3	6	3	20
Competing or higher priorities	3	3	3	5	3	17
Framing of extreme heat	3	4	3	5	1	16
COVID-19 pandemic	1	4	1	4	3	13
Staff	1	2	1	5	3	12
Co-benefits	3	1	2	3	0	9
Compounding impacts	1	1	0	1	1	4
Time	0	0	1	1	1	3