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Linking Urban Greening and Community Engagement with Heat-Related Health Outcomes: A Scoping Review of the Literature

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Abstract. Climate change has amplified the effects of extreme heat events (EHEs), exacerbating heat-related morbidity and mortality, particularly in cities due to the urban heat island effect. While a long-term solution to mitigating heat exists via urban greening, less is known about how to implement an urban greening plan co-designed by community members that addresses heat-related health outcomes. To examine the current state of urban greening interventions focused on communities and heat mitigation, we conducted a scoping review of papers at the nexus of urban greening/forestry, heat-related health outcomes, and community engagement. We then evaluated 46 eligible papers using a conceptual framework informed by the literature with the following criteria: (1) identification of urban green space/trees for climate change-amplified heat mitigation with quantifiable benefits; (2) association between objective heat-related health outcomes/health equity and urban greening intervention design; and (3) sustainable and ongoing community engagement and/or community co-creation. We found multiple differences between study methods. Most papers lacked objective heat-related health outcomes data and instead focused on subjective thermal comfort/heat stress measures. Additionally, almost all papers utilized one-time community engagement methods such as surveys or interviews to inform urban greening recommendations or study findings. Our findings have useful implications for urban greening decision-making, further emphasizing the importance of transdisciplinary cooperation and long-term community engagement, so an equitable, context-dependent urban greening and health intervention can be effectively co-produced by city planners, public health officials, and community members.

Keywords. Community Engagement; Environmental Justice; Extreme Heat; Heat-Related Health; Public Health; Urban Forestry; Urban Greening.

INTRODUCTION

Climate change is resulting in an increasingly warmer and more variable climate (Watts et al. 2015), promoting the frequency and severity of extreme heat events (EHEs)(Meehl and Tebaldi 2004; Habeeb et al. 2015). EHEs, including heat waves, have become the most deadly extreme weather event; in the United States alone, there were an average of 702 heat-related deaths each year from 2004 to 2018 (Vaidyanathan et al. 2020; National Weather Service [date unknown]). Exposure to extreme heat can also cause widespread heat-related illness and worsen other health conditions, such as respiratory conditions, sleep disorders, cardiovascular disease, digestive illness, psychological distress, and risk of preterm birth (Gasparrini et al. 2017; Sun et al. 2019; Chersich et al. 2020; Marí-Dell'Olmo et al. 2022).

Excess heat is a particularly pronounced issue in cities, where the majority of the global population now lives (World Bank Group 2022). In urban areas, heat is exacerbated by the urban heat island (UHI) effect, wherein higher air and surface temperatures regularly develop in contrast to surrounding rural areas. UHIs are formed through a combination of a lack of vegetation cover, greater heat storage from solar radiation within urban materials, and a wide range of sources of anthropogenic heat (e.g., combustion engines; heating, ventilation, and air conditioning systems; and human metabolism)(Oke 1982; Taha 1997; Zhao et al. 2014). Efforts to reduce heat-related health issues in urban environments are primarily focused on short-term adaptative solutions (e.g., air conditioning, access to cooling centers, or heat advisory messaging) rather than long-term planning (Vaidyanathan et al. 2019; Patel et al. 2022). Short-term solutions such as air conditioning face challenges such as high energy costs for low-income residents (Lundgren-Kownacki et al. 2018) and collapse of energy infrastructure; therefore, if a black out occurs and limits air conditioning availability during times of high demand, or if a household cannot afford to turn on air conditioning, the threat of extreme heat exposure will be greatly increased (Stone et al. 2021). A recent study found that heat wave and grid failure events can expose between 68% to 100% of urban residents to an elevated risk of heat-related illness (Stone et al. 2021).

Social-ecological systems research focuses on the complex interactions between humans and nature; for example, this research may assess a system's adaptive capacity and available resources to respond to climate change consequences such as extreme heat (Ostrom 2009; Pant et al. 2015). A proven long-term solution to mitigating the effects of urban heat through natural resources is the expansion of quality urban green space (Hu and Li 2020; Wong et al. 2021; Zhao et al. 2021), which encompasses all vegetation in cities (e.g., parks, street trees, greenways, stormwater beds, vegetation on private land, and community gardens). Solutions that use nature to address complex socio-ecological challenges, such as climate change mitigation/adaptation and human health, are termed nature-based solutions (Dunlop et al. 2024). For example, maintaining and expanding urban forest cover is a nature-based solution to mitigate climate change effects in cities and is of burgeoning interest to urban planners due to the myriad benefits provided by trees, including cooling through shading and evapotranspiration (i.e., latent heat loss through water vaporization through plant stomata and on surfaces)(Eisenman et al. 2021). Other urban greening interventions besides tree planting include the installation of "green roofs", "green corridors", and community gardens—all of which would also be a form of nature-based solutions. During EHEs, the surface temperature of shaded areas may be up to 20 °C cooler than unshaded areas, and evapotranspiration alone can reduce air temperatures by 1° to 8 °C (Winbourne et al. 2020). Beyond cooling benefits, trees and urban green space provide an abundance of other ecosystem services, including stormwater management, soil stabilization, cultural and aesthetic benefits, mental health improvement, and air pollution mitigation (Salmond et al. 2016; Berland et al. 2017; Woodward et al. 2023).

Despite these known benefits, green space in cities is inequitably distributed across neighborhoods; in other words, some communities face environmental injustice through the unequal distribution of environmental burdens (McPhearson et al. 2013; McDonald et al. 2021). Communities facing environmental injustice with limited access to quality green space often have a higher proportion of marginalized individuals, including people of color and the socio-economically disadvantaged (Schwarz et al. 2015; Nyelele and Kroll 2020; Forest for All NYC 2021). Tackling complex issues such as climate change-related health inequity requires a social ecological approach (Golden and Earp 2012). An individual's socio-economic status, sociopolitical identities, access to quality healthcare and education, and the surrounding built and natural environment are examples of social determinants of health—all factors that influence an individual's health status (US Department of Health and Human Services [date unknown]; Chelak and Chakole 2023). Together with spatial inequities in urban green space, the social determinants of health may multiply the risks of extreme heat events and heat-related illness in already vulnerable communities (Schmeltz et al. 2015; Schell et al. 2020; Vaidyanathan et al. 2020; Jung et al. 2021).

In recent years, city agencies have become increasingly cognizant of and have taken steps to reduce these inequities to improve environmental justice. For example, in New York City (NYC), the NYC Parks Department hosts tree care volunteer events in neighborhoods with high heat vulnerability to encourage expanding tree canopy cover and the ensuing cooling benefits (New York City Department of Parks & Recreation [date unknown]). Furthermore, other studies have recognized the importance of incorporating community participation in green space design; Oosterbroek et al. (2024) implemented a framework for active participatory green space design that incorporates community preferences and health data (Oosterbroek et al. 2024). Nevertheless, urban greening interventions are often implemented without input from communities, which can result in vegetation planted in unwelcome locations (Barbuti 2023) and can result in unintended consequences such as green gentrification (Anguelovski et al. 2022). Urban greening may also introduce other disservices to the community, including safety concerns, inadvertent health consequences (e.g., allergenic pollen), and physical damage to property (Lyytimäki et al. 2008; Conway and Yip 2016). Therefore, as cities choose to expand and improve upon urban green space with good intentions for the long-term health of the community, it has become increasingly necessary to engage communities in green space trade-off assessments and decision making (Roman et al. 2021).

As heat-related deaths and hospitalizations rise (Vaidyanathan et al. 2024), the direct connections made between urban greening programs and heat-related public health policies and tools grow in importance: a link that is needed for climate and health policy makers. For example, the US National Integrated Heat Health Information System (NIHHIS) and the White House developed a National Heat Strategy to "build societal understanding of heat risks, develop science-based solutions, [and] improve capacity, communication, and decision-making to reduce heat-related illness and death" (National Integrated Heat Health Information System 2024b). This strategy recognizes the importance of green space, green infrastructure, and nature-based solutions as vital components of heat-related health and resilience (National Integrated Heat Health Information System 2024a). Public health initiatives such as this one urgently require studies that assess urban greening and heat-related health to build evidence-based, long-term solutions to protect those most vulnerable to the effects of rising temperatures.

Therefore, we undertook a literature review at the nexus of urban greening, heat-related health outcomes, and community engagement to explore the state of the current research across disciplines and to evaluate the strengths of the literature that will most effectively guide evidence-based research and planning of urban greening programs and therefore improve heat-related health and health equity.

METHODS

Scoping Review

For our literature review, we conducted a scoping review, which has recently been defined as "a type of evidence synthesis that aims to systematically identify and map the breadth of evidence available on a particular topic", and can assist with identifying key concepts or themes within the literature (Munn et al. 2022). To do so, we systematically examined the literature across multiple databases and employed the inclusion and exclusion criteria to derive a final list of relevant manuscripts. We developed our inclusion and exclusion criteria through consensus. Our inclusion criteria were manuscripts that focused on all 3 of the following: (1) Urban Forestry, Urban Greening, or Urban Green Infrastructure; (2) Heat-related health outcomes; and (3) Community perception or community engagement. Papers met the first requirement if they mentioned any form of urban greening or urban green infrastructure (e.g., tree planting) in the context of heat mitigation. Papers met the second requirement if they explicitly connected heat with health outcomes data (e.g., mortality rates, hospitalization rates, self-reported health data). This criterion was based on the definition of health outcomes, which can be measured clinically, self-reported, or observed, and are health events occurring at the "result of an intervention"; in this study, this is the health event due to heat (Oleske and Islam 2019). Papers met the third requirement if they utilized direct community engagement through qualitative or quantitative research methods (e.g., questionnaire surveys or focus groups) with a defined community (e.g., geographic, identity) that focused on community perceptions. Excluded studies were: (1) non-English language studies; (2) nonhuman population studies; or (3) studies that only assessed rural communities. The search was completed on 2024 October 21 in PubMed, Web of Science (Core Collection; Clarivate, Philadelphia, PA, USA), and Scopus (Elsevier, Amsterdam, Netherlands) and included appropriate controlled vocabulary and keywords for the concepts of "greening", "community", and "heat-related health". The full search strategy can be found in the supplementary materials section (Supplementary File 1).

After deduplication, we screened 2,505 studies for inclusion using Covidence systematic review software (Veritas Health Innovation, Melbourne, VIC, Australia), a software that is agnostic to discipline and has been used in a variety of disciplines including the health sciences. First, we screened titles/abstracts, and then we screened full-text papers against the inclusion/exclusion criteria. Eligibility was determined by at least 2 screeners independently per paper, and conflicts were resolved through consensus meetings.

The PRISMA diagram outlining the process described above is presented in Figure 1 and was created using the Covidence PRISMA tool.

Data Extraction and Evaluation

We then extracted and summarized the following information from each included study: Author/Year and Title, Location, Köppen Climate Classification, Definition of Community Engaged, Method of Community Engagement, Urban Greening Description or Definition, Heat-Related Health Outcome, and Summary of Findings (Table 1). All figures and tables for data extraction were created with Microsoft Excel (Microsoft, Redmond, WA, USA). Subsequently, we evaluated how each study aligned with a framework adapted from the conceptual tree-planting framework devised by Hopkins et al. (2022). This framework allowed us to categorize the papers that address the intersection of heat-related health, urban greening interventions, and community engagement using a "multisectoral, collaborative, and environmental data driven approach" (Hopkins et al. 2022). We adapted this framework for evaluating the scope of the literature because of the acceleration of climate change-amplified extreme heat events and because of the growing need for evidence-based research that is particularly useful for climate and health decisionmakers and policy (National Integrated Heat Health Information System 2024a).

Rationale for Adapted Evaluation Criteria

The evaluation criteria of eligible papers were as follows: Criteria #1. Identification of urban greening/forestry/other nature-based solutions for climate change-amplified heat mitigation with quantifiable benefits; Criteria #2. Association between objective heat-related health outcomes/health equity and urban greening interventions; and Criteria #3. Sustainable and ongoing community engagement and/or community co-creation.

Criteria #1, the quantification of urban greening benefits, is well-studied, particularly in the context of ecosystem services, which are the benefits humans receive from ecosystems, and are often classified as either provisioning, regulating, supporting, or cultural services (Millennium Ecosystem Assessment 2005). Understanding ecosystem services in urban planning research helps to explain how humans benefit from the natural environment in the complex socio-ecological system of a city, as well as to estimate the economic value of the benefits (de Groot et al. 2012; Kremer et al. 2015). Estimates of ecosystem services inform local, state, and federal plans and policies that utilize the natural ecosystem for public health benefits and climate change resilience (Kremer et al. 2015; Kapoor et al. 2020). Papers fit Criteria #1 if the study found quantifiable climate-amplified heat mitigation benefits from urban greening, such as through biometeorological/microclimate measurements, spatial modelling, or subjective experiences.

Criteria #2, the association between objective heat-related health outcomes/health equity and urban greening, further emphasizes the importance of quantifying benefits from urban greening, but from a public health perspective. A plethora of studies have found strong evidence for green space benefits on public health outcomes, both physical and mental (Kruize et al. 2019). That said, fewer studies have measured objective health outcomes from urban greening, despite the importance of health metrics to urban greening design and implementation (Zhang et al. 2021) and the persistence of health inequities in communities facing environmental injustice (Hopkins et al. 2022). As extreme heat events increase, it will become particularly important that objective heat-related health outcomes data is included as well to strengthen public health data access for policymakers (US Centers for Disease Control and Prevention 2024). Papers therefore fit Criteria #2 if the study utilized objective heat-related health outcomes/health equity data to inform urban greening research and planning.

Finally, Criteria #3, sustainable and ongoing community engagement and/or community co-creation, was our final criterion and another topic that has been well-established in the environmental justice literature, which emphasizes the importance of meaningful community involvement in nature-based solutions. Historical systemic injustices often shape current patterns of heat-related health inequity and environmental injustice, and interventions that lack community engagement heighten the probability of perpetuating inequities (i.e., green gentrification)(Amorim-Maia et al. 2022). This criterion also emphasizes the importance of understanding axes of vulnerability and establishing community buy-in to redistribute power and benefits to those facing environmental injustice (i.e., procedural justice). Co-production of green space not only improves the chances of planting success and increased health benefits but also fosters strong community ties and social cohesion (Bhandari 2023). Therefore, environmental justice-focused research and interventions require further interaction with communities beyond surveys and the maintenance of long-lasting and collaborative relationships with communities (Amorim-Maia et al. 2022). Papers met Criteria #3 if they had evidence of more than one touchpoint with communities (e.g., through meetings), and incorporated elements such as co-creation, education, or engagement events in their study design.

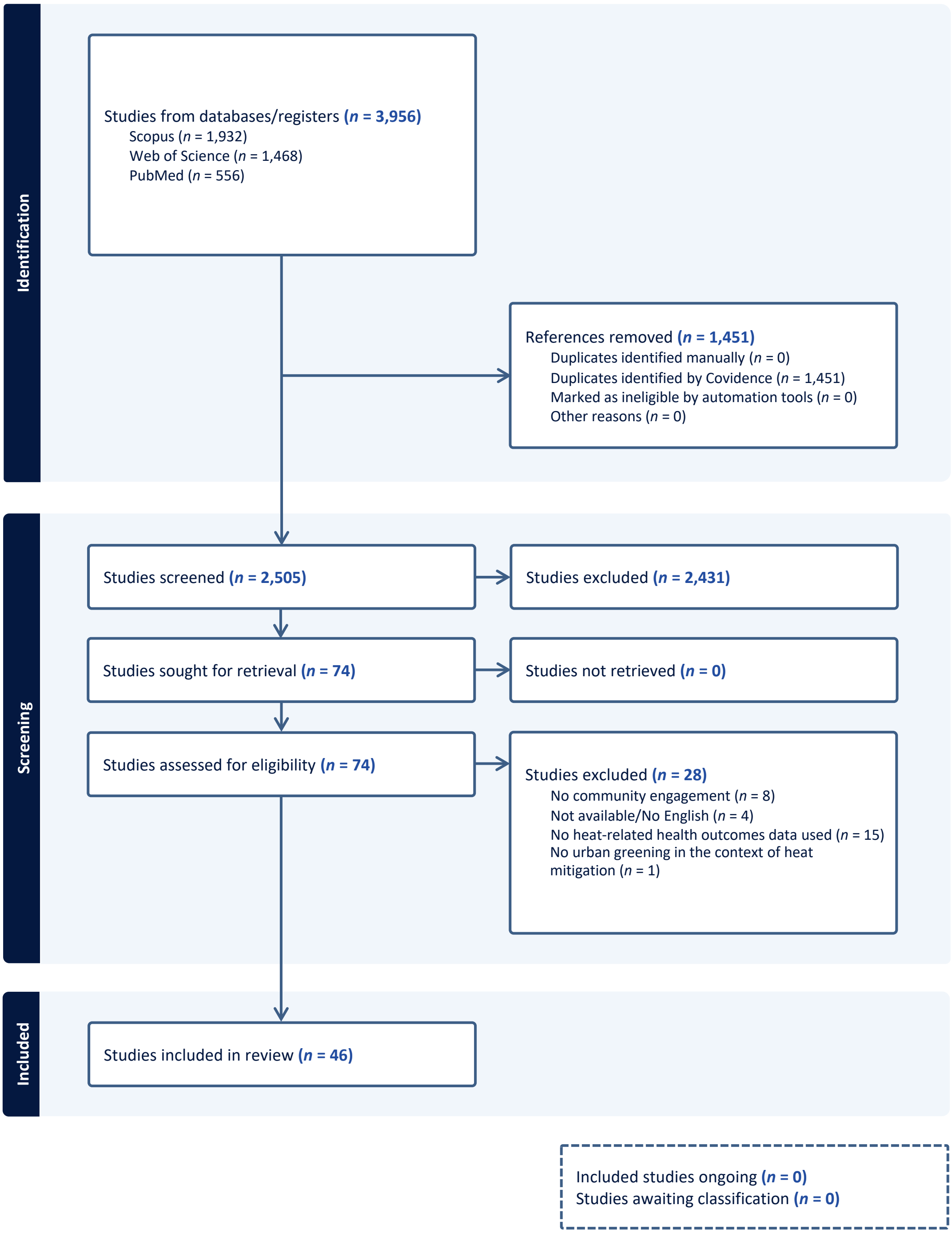

Figure 1. PRISMA diagram of review process.

RESULTS

Characteristics of Included Papers

In Table 1 we summarized 46 studies which met the criteria for inclusion in the analysis. Of the studies, half were from Asia (23/46: Malaysia, China, Singapore, India, Pakistan, Saudi Arabia, and Thailand), and most of the remaining half were from North America (10/46: United States and Mexico) and Europe (11/46: Germany, Cyprus, The Netherlands, Spain, Austria, United Kingdom, and Italy), with one each from South America (Brazil) and Australia (Melbourne) and none from Africa. The majority of the studies (34/46) were conducted in temperate climates ("C" Köppen climate classification: Csa, Csb, Cfa, Cwa, Cfb), with the next most common climate (9/46) being dry (arid)("B" Köppen climate classification: BWh, BSk, BSh), and then tropical (4/46)("A" Köppen climate classification: Af, Aw), and finally continental (2/46)("D" Köppen climate classification: Dwa). The counts for climate classification add up to more than 46 due to the occurrence of more than one climate classification in some studies, either due to multiple study sites (Lafortezza et al. 2009) or due to 2 known classifications in one location (Giannakis et al. 2016). Results can be found in Figure 2 and Figure 3.

The majority of studies utilized surveys as the means of community engagement methods (i.e., online, in-person, mail-back, telephone) or semistructured interview only (41/46). The other 5 had some form of community co-creation or further engagement (e.g., participatory planning, ecological stewardship events, educational workshops). One of the studies used physiological measurements along with surveys (Rathmann et al. 2020). Results can be found in Table 2.

When discussing urban greening, over 80% of studies used the phrase "urban green space", "urban green area", or "urban greening" (38/46) and/or "urban forest" or "trees" (40/46). Nearly a third of studies (15/46) described "green infrastructure" and/or described greenspace as "vegetation" (14/46). About 22% described urban greening as an "intervention" (10/46)(e.g., "urban heat intervention", "greening intervention", "tactical urbanism intervention", "tree planting intervention", "climate intervention", "mitigation/adaptation intervention", etc.). Finally, only 17% (8/46) described "nature/natural-based solutions". Results can be found in Table 3.

Lastly, for heat-related health outcomes, the overwhelming majority of papers used self-reported measures of heat stress, thermal comfort, or heat-related illness (43/46). Only 5 papers reported some objective measure of heat-related health (e.g., morbidity and mortality rates, physiological measurements, hospitalization/ambulance records). Two papers included both subjective and objective measures (Guardaro et al. 2020; Rathmann et al. 2020). Results can be found in Table 4.

Conceptual Framework Evaluation

According to our adapted framework, 40 papers met Criteria #1: Identification of urban greening/forestry/other nature-based solution for climate change-amplified heat mitigation with quantifiable benefits; 5 met Criteria #2: Association between objective heat-related health outcomes/health equity and urban greening interventions; and 5 met Criteria #3: Sustainable and ongoing community engagement and/or community co-creation. Two papers met all three criteria: Hopkins et al. (2022), the paper that our criteria were modelled after; and Nahban et al. (2020). Both papers identified a type of urban greening intervention to mitigate climate-amplified heat in urban areas; presented objective heat-related health outcomes specific to that region; and performed meaningful community engagement. In Hopkins et al. (2022), this was accomplished through a tree planting framework that was developed by expert stakeholders to identify and rank a list of native tree species based on their physiology and climate-related ecosystem services. Then, locations to plant the trees with the best climate-mitigation rankings were chosen based on maps depicting high rates of cardiac arrest and asthma attacks. The previously mentioned steps engaged multiple stakeholders within each step, but after trees and locations were chosen, additional partners were engaged across many other sectors through meetings, lectures, webinars, and on-site tree demonstrations (Hopkins et al. 2022). In Nabhan et al. (2020), the authors identified the consistent positive benefits received from a youth ecological restoration program, including sense of community and improved emotional and physical strength. Then, they identified the importance of restoration engagement efforts to mitigate rising rates of coccidiomycosis (valley fever) in the desert Southwest in the United States, a heat-exacerbated disease that can be reduced with habitat restoration in desert environments. Finally, they emphasized the importance of ecological restoration programs as ways to engage youth in not only scientific research and discovery but also in the restoration of their own health and well-being as well as the health of their environment (Nabhan et al. 2020).

The papers that met Criteria #1 explicitly quantified urban greening benefits in the context of heat mitigation through either objective or subjective measures (and often with both). The mechanisms for assessing urban greening benefits fell within categories established by Zhang et al. (2021): (1) heat mitigation benefits provided by urban green space; (2) heat-related physiological and psychological effects; and (3) healthy behaviors (i.e., climate mitigation and adaptation strategies) motivated by green space. For example, Maghrabi et al. (2021) assessed resident perceptions of the role of green space through surveys and found that 85% of the respondents saw green space as playing a "crucial" role in temperature regulation and urban heat island effect reduction (Maghrabi et al. 2021). Similarly, Sousa-Silva and Zanocco (2024) evaluated residents' perceived benefits of green space as well as heat adaptation behaviors associated with green space, finding that despite positive attitudes towards green space, fewer than 20% of the respondents visited green spaces on hot days (Sousa-Silva and Zanocco 2024). By contrast, Rosso et al. (2024) used microclimate measurements to determine that air temperature was marginally cooler in urban pocket parks in New York City, NY, USA, compared to the surrounding streets, and different park types had varying levels of cooling efficiency (Rosso et al. 2024).

The papers that met Criteria #2 used objective heat-related health outcomes to inform urban greening designs or recommendations. For example, Huanchun et al. (2021) created a simulation of potential green space designs based on reducing the urban heat island effects on respiratory disease, cardiovascular disease, and emotional health. In another example, but with different methods, Rathmann et al. (2020) explored the positive effects of urban greening on heat-related well-being through human physiological measures (e.g., blood pressure readings) and found that urban greening did have positive effects on human physiological measures (e.g., reduction in heart rate). Other studies utilized hospitalization or ambulance records to explain heat-related health outcomes and inform green space design (Kilbourne et al. 1982; Hopkins et al. 2022).

The papers that met Criteria #3 varied in their goals, which may be due to the plethora of ways that community engagement can occur. For example, Nabhan et al. (2020) focused on ecological restoration programs as a way to engage at-risk youth with nature-based interventions to improve both human and ecosystem health during extreme heat. Oosterbroek

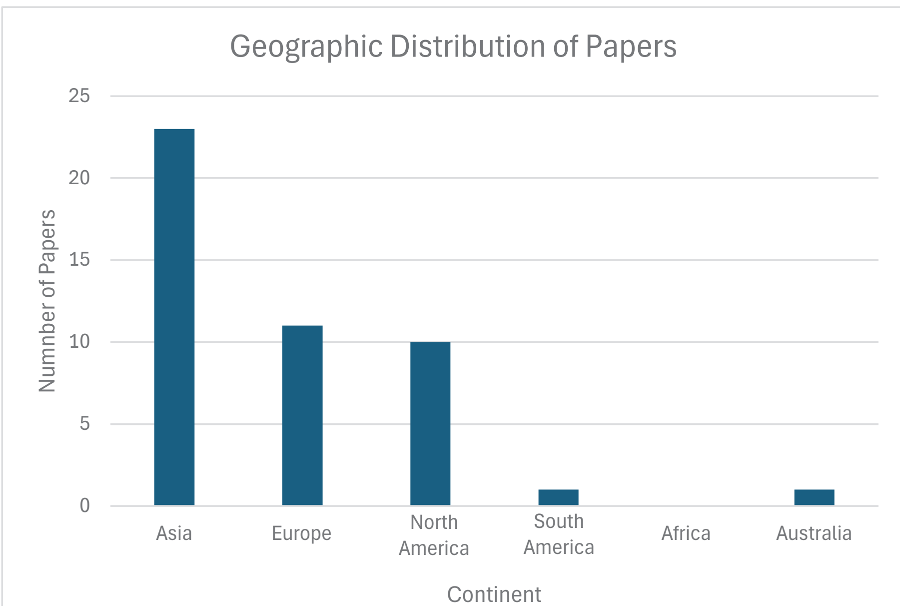

Figure 2. Geographic distribution of papers.

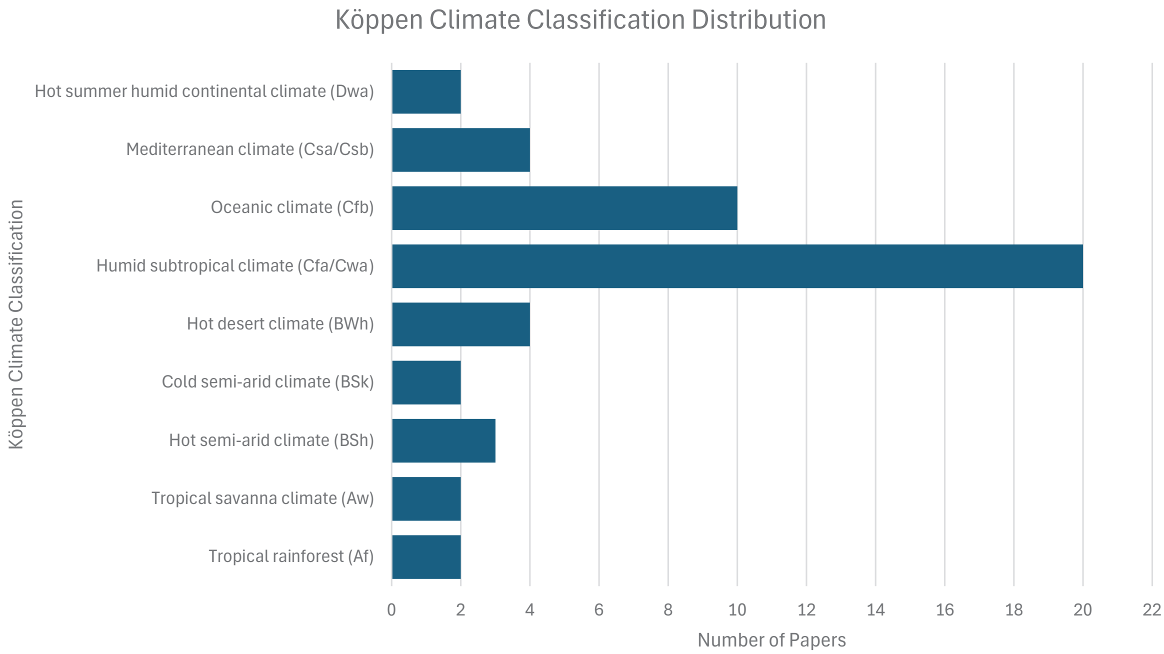

Figure 3. Köppen climate classification distribution.

et al. (2024), on the other hand, provided an example of participatory green space design with elderly and youth residents through multiple design meetings and iterations. Other studies emphasized multistakeholder engagement meetings and educational community workshops (Guardaro et al. 2020; Ehsan et al. 2021; Hopkins et al. 2022).

Results and examples from papers can be found in Table 5.

DISCUSSION

Our scoping review found 46 eligible papers at the nexus of urban greening, heat-related health outcomes, and community engagement. To further assess the gaps in the literature and potential areas of future research, we evaluated the 46 eligible papers using a framework adapted from a tree planting framework created by Hopkins et al. (2022). Our adapted framework recognized studies that identified quantifiable heat mitigation benefits of urban green/forestry/other nature-based solutions, associated urban greening interventions with objective heat-related health outcomes, and/or engaged meaningfully with communities of interest. Through this evaluation, we found that there were key differences in research context, methods, and empirical questions between studies.

For example, most of the studies we assessed were focused on urban climatology and biometeorology methods to inform urban planning. This included studies that quantified subjective and objective thermal data (e.g., thermal comfort, heat stress, physiological equivalent temperature) in urban areas but were not as focused on providing quantifiable heat-related health/thermal comfort benefits of urban greening (Li et al. 2023). Papers that did measure quantifiable urban greening benefits often assessed self-reported health outcomes or healthy behaviors due to green space and did not consider objective heat-related health outcomes (e.g., mortality rates, hospitalization admissions)(Maghrabi et al. 2021). Finally, few of the studies engaged with communities repeatedly and meaningfully, primarily utilizing one-time surveys and interviews, a finding that is similar to other studies that evaluate equity in green infrastructure planning (Grabowski et al. 2023).

This is the first review of our knowledge to evaluate the literature at this intersection and highlights several opportunities to bring together 3 core ideas of growing interest nationally and internationally—the use of nature-based solutions to protect against the health effects of extreme heat, particularly among vulnerable communities. For example, in the United

States, the previously mentioned National Heat Strategy calls for quantifiable public health and urban forestry benefits, particularly to add sophistication to economic valuation of urban greening (National Integrated Heat Health Information System 2024a).

Future research can therefore benefit from comparing biometeorological and subjective thermal data with objective heat-related health outcomes (e.g., heat-related mortality rates or hospitalization admissions) to further inform green space design and placement, particularly because this type of health outcomes data is useful for public health policy and interventions (US Centers for Disease Control and Prevention 2024). Furthermore, additional comparisons in heat-related health outcomes for vulnerable groups will help provide an intersectional lens to identifying mechanisms for adverse health outcomes. Areas disproportionately vulnerable to heat stress can then be prioritized for greening interventions (The City of New York 2017; Hopkins et al. 2022).

Our emphasis on the importance of community engagement is rooted in the legacy of environmental justice, which requires procedural justice in environmental planning through community outreach and participatory methods (Schlosberg and Collins 2014). While most of the 46 studies fall short when it comes to long-term community engagement methods, some of the studies we analyzed were environmental justice-focused through recognizing vulnerable populations and the distribution of environmental injustice. For example, Gabbe et al. (2023) and Cronley et al. (2024) were focused on examining the experiences of people experiencing homelessness during extreme heat events (Gabbe et al. 2023; Cronley et al. 2024). Other studies compared neighborhoods with different levels of socio-economic advantage (Mittermüller et al. 2021) or specifically focused on areas with socio-economic disadvantage (Bai et al. 2013; Lanza et al. 2023). Finally, multiple studies also focused on analyzing the thermal comfort/heat stress according to older adults who are particularly vulnerable to extreme heat (Yung et al. 2019; Li et al. 2023). Future studies should continue to address the distribution of injustice and recognize who is most affected by injustice while also paving the way for procedural justice for communities in decision-making, all research goals that are aligned with the 3 tenants of environmental justice: distributional, recognitional, and procedural justice (Schlosberg and Collins 2014).

Our findings also underscore the importance of multistakeholder collaboration for teams seeking to limit the health-related impacts of heat waves through green interventions. Transdisciplinary multistakeholder collaboration involves community-specific viewpoints on urban greening and its relation to health, including acknowledgement of the competing interests of communities (e.g., immediate needs about housing, education, healthcare, personal safety) and communication on investing in long-term solutions that will alleviate future climate-related risk. Our results can aid in facilitating transdisciplinary discussions by sharing the various definitions, terms, and methods utilized in the literature to describe urban greening, community engagement, and heat-related health. Shared language is another important factor in operationalizing transdisciplinary research (Cannon 2020).

Finally, our results also revealed limited geographical and climatological reach. There were no studies that met our inclusion criteria from Africa and only one from South America, two continents often underrepresented in urban greening literature, despite increased climate-amplified extreme heat and climate injustice in countries in the Global South (Ogunbode 2022). Additionally, these continents have largely tropical and dry (arid) climates, which were also underrepresented in our findings yet particularly susceptible to climate change-amplified extreme heat (Harrington and Otto 2020; Ehsan et al. 2021). Global environmental and climate justice calls for future research that prioritizes underrepresented countries and climates, using diverse methods of engagement (Ogunbode 2022). These include culturally specific tools including the role of various faith and religious beliefs in community health and urban greening/forestry, a theme notably absent from the analyzed studies. There is a growing body of urban greening literature informed by organized religion that emphasizes stewardship of the earth, trees, and ecosystems as integral to religious beliefs (e.g., Christianity, Islam, and Hinduism) and the interconnectedness of all living beings and the need for harmonious coexistence with nature (Coward 2003; Jusoff and Samah 2011; Gnanakan 2015). This gap reveals a potential research agenda for the future of addressing heat risk, community engagement, and urban greening that extends beyond current equity-focused work (Grabowski et al. 2023).

Table 1. Description of papers. PEH (persons experiencing homelessness); LST (land surface temperature); PET (physiological equivalent temperature); mPET (modified physiological equivalent temperature); COMFA (COMfort ForumIA); SDU (subdivided units); GS (green space); UGS (urban green space); UHI (urban heat island); UHIR (urban heat island reduction); PP (pocket parks); IP (interim plazas); POP (privately owned public spaces); GIS (geographic information system).

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Arifwidodo and Chandrasiri 2020 "Urban heat stress and human health in Bangkok, Thailand"	Bangkok, Thailand, Asia	Tropical savanna climate (Aw)	Residents (n = 505) of Bangkok, Thailand	Questionnaire survey face-to-face with randomly selected registered households from the Bangkok Metropolitan Administration	Parks as a type of green space	Self-reported heat stress and health outcomes	This study evaluated the determinants of heat stress and the effects of heat stress to human health in Bangkok, Thailand, using a survey questionnaire. The results indicated that a significant determinant of heat stress is socioeconomic status, with low-income populations more likely to experience heat stress. Furthermore, respondents who reported heat stress were more likely to have adverse health outcomes.
Bai et al. 2013 "Rapid warming in Tibet, China: Public perception, response and coping resources in urban Lhasa"	Lhasa, Tibet, China, Asia	Cold semi-arid climate (BSk)	Residents (n = 619) of urban Lhasa, Tibet	Face-to-face questionnaire surveys of residents previously informed by a Community Committee about the study	Green spaces include green parks and other vegetation	Self-reported presence of heat-related illness (dizziness, tiredness, irritability, thirst, loss of appetite, headaches, nausea, vomiting, and muscle weakness)	This study explored the subjective experiences of heat-related symptoms and behavior changes for residents of Lhasa, Tibet, through a questionnaire survey. The study found that nearly 40% of respondents reported heat-related symptoms, of which risk perception was influenced by sex, age, education, and income. The vast majority of respondents reported changing their behavior on hot days.
Callejas and Krüger 2022 "Microclimate and thermal perception in courtyards located in a tropical savannah climate"	Cuiaba, Brazil, South America	Tropical savanna climate (Aw)	Visitors (n = 178) to courtyards in Cuiaba, Brazil	In-person questionnaire survey conducted in 2 courtyards in the historic city center	Greenery in courtyards include palm trees, vines, and other vegetation	Self-reported heat stress and thermal comfort	This study evaluated courtyard morphology and subject thermal perception through microclimate data and a questionnaire survey of courtyard visitors in Cuiaba, Brazil. The findings demonstrated that the geometric shape of the courtyard was significant to provide thermal relief for visitors due to shading and solar access.

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Cronley et al. 2024 "Persons experiencing homelessness during extreme temperatures: Lessons for promoting socially inclusive adaptive capacity"	Knoxville, TN, USA, North America	Humid subtropical climate (Cfa)	PEH ($n = 42$) in Knoxville, TN, USA	Semi-structured interviews that included cross-sectional, semi-structured, and open-ended questions	Green infrastructure includes natural elements such as trees, parks, green roofs, and other green spaces	Self-reported heat-related injuries (e.g., dehydration, heat cramps)	This study explored the lived experiences of PEH during extreme temperatures in Knoxville, TN, USA, through in-depth interviews. The findings revealed barriers to PEH's adaptive capacity to extreme temperature, such as restricted mobility. The authors recommended the importance of destigmatizing homelessness and designing inclusive green infrastructure.
de Guzman et al. 2023 "Cooler and healthier: Increasing tree stewardship and reducing heat-health risk using community-based urban forestry"	Los Angeles, CA, USA, North America	Warm-summer Mediterranean climate (Csb)	Households ($n = 116$) in Los Angeles County, CA, USA	Pre- and post-intervention mail-back questionnaire survey	Urban greening includes tree planting	Self-reported heat-related health symptoms including headaches, dizziness, tiredness, and nausea/vomiting	This study assessed the impacts of community engagement approaches on values and behaviors related to street tree stewardship and heat-mitigation behaviors in households in Los Angeles County, LA, USA. The study tested a control intervention with community engagement experimental messaging and measured outcomes including tree health and survey responses. The findings demonstrated that intervention messages had little effect on the measured outcomes, but tree stewardship was positively correlated to heat protection measures.
Deilami et al. 2022 "Resilience and adaptation strategies for urban heat at regional, city and local scales"	Melbourne, Victoria, Australia	Oceanic climate (Cfb)	Visitors ($n =$ 1,059) of case study sites in Melbourne, Victoria, Australia	In-person questionnaire surveys at study site	Green zones are defined as vegetation. Increasing the "extent of green zones in cities" can look like "planting trees, building parks and gardens and increasing the area of green roofs and walls"	Self-reported thermal comfort	This chapter focused on the experiences of 3 case studies in Australia that are mitigating urban heat island effects. The case studies included satellite imagery, spatial modelling, and community engagement methods to strategize resilience and adaptation strategies for extreme urban heat. The chapter concluded with an emphasis on the importance of both biometeorological conditions and thermal perceptions in urban planning for heat mitigation.

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Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Ebenberger and Arnberger 2019 "Exploring visual preferences for structural attributes of urban forest stands for restoration and heat relief"	Vienna, Austria, Europe	Oceanic climate (Cfb)	Users (n = 160) of an urban public green space in Vienna, Austria, that stayed in the park for at least 30 minutes and lived in urban or suburban areas	In-person questionnaire survey including a visual discrete choice experiment that explored user preferences for 4 different forest stand types	Green infrastructure and green space include trees and woodland	Self-reported heat sensitivity and heat stress during periods with high temperatures	This study explored the preferences and trade-offs for structural components of urban forests with heat relief, restoration, and aesthetic preference through a questionnaire survey and discrete choice experiment for park users in Vienna, Austria. The results showed that park users would prefer a less aesthetically pleasing forest structure for the benefit of heat stress relief on hot days.
Ehsan et al. 2021 "Thermal discomfort levels, building design concepts, and some heat mitigation strategies in low-income communities of a South Asian city"	Faisalabad, Pakistan, Asia	Hot semi-arid climate (BSh)	Residents in households (n = 52) of low-income communities in Faisalabad, Pakistan	Awareness seminars followed by in-person questionnaire surveys	Greenery includes trees, shrubs, and other vegetation	Self-reported heat-related health issues (e.g., diarrhea, dehydration, headache, fever)	This study assessed thermal discomfort levels, building design concepts, and heat mitigation strategies during adverse heat-related health events in low-income neighborhoods in Faisalabad, Pakistan, through weather station data, the thermal discomfort index, and questionnaire surveys. The study found that heat-mitigation strategies are gender-biased; for example, 52% of males and 28% of females drank more water during dehydration. The study recommended urban greening interventions (trees, open parks) to help mitigate heat-related health complaints.
Franck et al. 2013 "Heat stress in urban areas: Indoor and outdoor temperatures in different urban structure types and subjectively reported well-being during a heat wave in the city of Leipzig"	Leipzig, Germany, Europe	Oceanic climate (Cfb)	Residents (n = 127) of Leipzig, Germany	Questionnaire survey delivered in mailboxes and workplaces	Green spaces include trees and other vegetation that reduces temperatures	Self-reported experience of heat stress	This study assessed how types of urban structures are related to urban temperature differences and how indoor temperatures depend on urban housing conditions through remote sensing and household survey data. The study found that green spaces are related to air temperature (more green means lower temperatures), indoor heat island effect corresponds to the outdoor effects, and self-reported heat stress varies according to adaptation behavior.

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Gabbe et al. 2023 “Reducing heat risk for people experiencing unsheltered homelessness”	Santa Clara County, CA, USA, North America	Warm-summer Mediterranean climate (Csb)	PEH ($n = 82$) in Santa Clara County, CA, USA	Exploratory interviews (“in-depth” semi-structured [$n = 10$] and “encampment” community-needs assessment [$n = 72$])	Tree canopy and green space associated with reducing heat exposure	Self-reported experiences with extreme heat, including physical health issues (dehydration, dizziness, fainting, etc.) and mental health/substance use issues	This study conducted a mixed methods approach (spatial analyses and interviews) to understand heat-related health exposure and risk to unhoused people. The study found that PEH often preferred to live in places with more stability but which tended to have less access to shade, water, and other cooling resources.
Giannakis et al. 2016 “Linear parks along urban rivers: Perceptions of thermal comfort and climate change adaptation in Cyprus”	Nicosia, Cyprus, Europe	Hot semi-arid climate (BSh) and Hot-summer Mediterranean climate (Csa)	Visitors ($n = 305$) to a park in Nicosia, Cyprus, on hot summer days	In-person questionnaire survey at Pedieos Park	Nature-based solutions include “green roofs and walls, street trees, and green areas and corridors”	Self-reported thermal comfort	This study explored the perceptions and satisfaction of thermal conditions in a park in Nicosia, Cyprus, on hot summer days through questionnaire surveys and micrometeorological measurements. The results indicated that 84% of visitors were satisfied with the cooling effect of the park, yet there were discrepancies between the observed thermal comfort index and people’s perceptions, indicating that people in semi-arid environments were adapted to the hot climatic conditions.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Guardaro et al. 2020 "Building community heat action plans story by story: A three neighborhood case study"	Phoenix, AZ, USA, North America	Hot desert climate (BWh)	Residents (*n* = 200) of 3 metropolitan Phoenix, AZ, USA, neighborhoods chosen due to factors such as high urban heat exposure and sensitivity, strong community identity, and entrenched community-based organizations	Nature's Cooling Systems community engagement methodology to engage, design, plan, and implement through educational meetings, design workshops, and heat action planning	Urban heat interventions include increasing tree and vegetation cover, as well as green roofs, and other green infrastructure projects	Self-reported thermal comfort and public health outcomes due to extreme heat assessed over time through continuous community engagement	This transdisciplinary study developed a methodology to engage heat-vulnerable populations in the co-creation of urban heat interventions through a case study in metropolitan Phoenix, AZ, USA. The result of cross-sector collaboration and participatory research was a community co-created heat action plan which recommends contextual neighborhood action, reinforcements of social networks, and implementation of policies that will advance heat adaptation.
Heng and Chow 2019 "How 'hot' is too hot? Evaluating acceptable outdoor thermal comfort ranges in an equatorial urban park"	Singapore, Asia	Tropical rainforest (Af)	Park visitors (*n* = 1,508) of the Singapore Botanic Gardens in both the winter and summer monsoon months	In-person questionnaire survey at study site	Urban greenery defined as "street trees, parks, and rooftop gardens" that "offer important provisional, support, cultural and regulatory ecosystem services"	Self-reported thermal (dis)comfort and physiological thermal stress	This study analyzed the outdoor thermal comfort of park users in Singapore to determine specific temperature ranges for (1) neutral, (2) acceptable, and (3) preferred temperatures through questionnaire responses and microclimate measurements. The findings demonstrated that the preferred ideal temperature for all residents is 24.2 °C, and changes between respondents were most likely due to differences in acclimatization.

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Hopkins et al. 2022 "A simple tree planting framework to improve climate, air pollution, health, and urban heat in vulnerable locations using non-traditional partners"	Houston, TX, USA, North America	Humid subtropical climate (Cfa)	Environmental community leaders and other community partners in Houston, TX, USA	Series of engagement/ education meetings, luncheons, lectures, webinars, video and in-person forums, and on-site tree species demonstrations	Green infrastructure includes urban trees and native tree species were selected according to their known ecosystem services	Rates of cardiac arrests and asthma attacks	This study adopted a multidisciplinary framework to adopt an evidence-based tree planting plan to improve climate adaptations and health outcomes in vulnerable neighborhoods in Houston, TX, USA. The framework included the identification of optimal native tree species for climate change adaptation and mitigation, the selection of vulnerable locations, and the engagement of multisectoral leadership for implementation. The result of this multidisciplinary project was the eventual planting of thousands of optimal native trees in vulnerable locations.
Huanchun et al. 2021 "Urban green space optimization based on a climate health risk appraisal—A case study of Beijing city, China"	Beijing, China, Asia	Hot summer humid continental climate (Dwa)	Residents ($n = 380$) of Beijing, China	In-person questionnaire survey	Green spaces described as vegetation that cools	Self-reported experiences of emotional health outcomes on hot days and mortality rates related to respiratory and cardiovascular disease on hot days	This study evaluated how Beijing's thermal environment influenced the health of residents through spatial modelling (satellite images, electronic maps, questionnaire survey data, numerical analysis). The findings showed areas in Beijing with greater urban heat island effects on respiratory disease, cardiovascular disease, and emotional health, and simulated interventions to reduce health risks (e.g., cooling nodes, green rings, pergolas).
Jenerette et al. 2016 "Micro-scale urban surface temperatures are related to land-cover features and residential heat related health impacts in Phoenix, AZ USA"	Phoenix, AZ, USA, North America	Hot desert climate (BWh)	Random sample of residents ($n = 806$) in Phoenix, AZ, USA	Phoenix Area Social Survey (PASS) conducted online, by telephone, or in person	Vegetated land cover including trees, grass, and green roofs mitigate land surface temperature	Self-reported health outcomes due to heat, including leg cramps, dry mouth, dizziness, fatigue, fainting, rapid heartbeat, or hallucinations	This study linked thermal imagery of Phoenix, AZ, USA, with social survey data on perceptions of heat illness to examine whether neighborhood LST characteristics correspond to residents' self-reported symptoms of heat-related illness. The results demonstrated that symptoms of heat-related illness were correlated with LST patterns during the daytime, but not during the nighttime.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Kabisch et al. 2021 "Impact of summer heat on urban park visitation, perceived health and ecosystem service appreciation"	Leipzig, Germany, Europe	Oceanic climate (Cfb)	Visitors (n = 176) of 2 inner-city parks in Leipzig, Germany, on hot summer days	In-person questionnaire survey at study site	Urban green space includes "forests, parks, cemeteries, and allotment gardens"	Self-reported health impairment during heat waves (e.g., exhaustion, concentration problems, sleep problems, headache, cardiovascular problems, and heat stress)	This study examined the perceptions of park visitors in Leipzig, Germany, on heat-related health impairment and activity patterns on hot days and the role of parks in coping with heat stress. The results demonstrated that visitors of the park with fewer trees and greenspace had significantly higher heat-related health impairment and had to adjust their visiting behavior accordingly.
Karimi and Mohammad 2022 "Effect of outdoor thermal comfort condition on visit of tourists in historical urban plazas of Sevilla and Madrid"	Seville and Madrid, Spain, Europe	Hot-summer Mediterranean climate (Csa) and Cold semi-arid climate (BSk)	Tourist visitors (n = 180) to outdoor plazas in Seville and Madrid, Spain, on hot days	In-person questionnaire survey at study sites	Vegetation cover including trees	Self-reported thermal comfort sensation and mental condition	This study assessed the thermal comfort of tourist visitors in urban plazas in Seville and Madrid, Spain, through microclimatic measurements, questionnaire surveys, and simulation results. The findings demonstrated that the outdoor thermal comfort range for tourists varied from 28.42 to 30.87 °C in Seville and 24.5 to 29.82 °C in Madrid. A comparison between the simulation results and the questionnaire demonstrated that, as expected, urban plazas with relatively high thermal stresses had higher self-reported thermal discomfort scores.

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Kilbourne et al. 1982 "Risk factors for heatstroke: A case-control study"	St. Louis and Kansas City, MO, USA, North America	Humid subtropical climate (Cfa)	Persons with heatstroke (*n* = 156) and persons without (*n* = 462) in Saint Louis and Kansas City, MO, USA	Questionnaire survey of patients with heatstroke and patients without (control) matched by age, sex, and neighborhood of residence. Whenever possible, interviews were conducted in person with patients or surviving family members	Trees and shrubbery described as a risk factor for nonfatal heatstroke	Assessed risk factors associated with heatstroke in patients presenting temperatures measured anywhere on the body greater than or equal to 41.1 °C, temperature greater than or equal to 40.6 °C if altered mental status or anhidrosis was also present, and those pronounced dead on arrival if body temperature was greater than or equal to 41.1 ° C	This study conducted a case-control study in St. Louis and Kansas City, MO, USA, of patients presenting with heatstroke and matched with control subjects to assess the risk factors associated with heatstroke. The study found that there were 6 main risk factors associated with nonfatal heatstroke, including extent of tree and shrubbery growth around the residence.
Kumar and Sharma 2022 "Assessing outdoor thermal comfort conditions at an urban park during summer in the hot semi-arid region of India"	Haryana, India, Asia	Hot semi-arid climate (BSh)	Park visitors (*n* = 55) in Haryana, India, in the summer months	In-person questionnaire survey at study site	Green urban open space, greenery, and green infrastructure can include urban parks and vegetation	Self-reported thermal comfort and thermal sensation	This study assessed the thermal comfort conditions of residents in an urban park in Haryana, a hot semi-arid city in India, through microclimate monitoring and questionnaire surveys. The findings demonstrated that the majority of visitors had thermal sensations between "slightly cool" to "slightly warm" which demonstrated the cooling present in the park. The neutral physiological equivalent temperature was found to be 24.04 to 37.5 °C.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Lafortezza et al. 2009 "Benefits and well-being perceived by people visiting green spaces in periods of heat stress"	Gateshead, England, United Kingdom; and Milan and Bari, Italy; Europe	Oceanic climate (Cfb) and Humid subtropical climate (Cfa)	Random sample of visitors (*n* = 800) to green spaces in Italy (*n* = 400) and the United Kingdom (*n* = 400)	In-person questionnaire survey at study sites	Green space defined as "city parks, urban woodlands, street trees, rooftop gardens, and vertical greening on buildings"	Self-reported psychological benefits (e.g., reduced depression, enhanced vigor, balanced feelings), and physical benefits (improving respiration, strength, metabolism) perceived during and after the visit on a hot summer day	This study assessed the question of whether green space visitors in Italy and the United Kingdom perceive benefits and enhance their well-being by visiting green spaces during periods of intense heat through structured interviews. The results indicated that both the time spent in green spaces and the number of times green space was visited significantly improved perceived benefits and well-being during periods of extreme heat.
Lam et al. 2024 "Effects of perceived environmental quality and psychological status on outdoor thermal comfort: A panel study in Southern China"	Guangzhou, China, Asia	Humid subtropical climate (Cfa)	College students (*n* = 14) from Guangzhou, China	In-person questionnaire survey for thermal walk experiment where participants were asked to fill out the survey questions at each stop along the thermal walk	Urban green space includes vegetation in cities such as trees and wetlands	Self-reported thermal comfort including psychological status, an early warning signal to morbidity and mortality linked to thermal stress	This study examined the perceived environmental quality and psychological status on outdoor thermal comfort for college students in Guangzhou, China, through "thermal walk" experiments. The findings demonstrated that psychological status (e.g., higher irritability or tiredness) was associated with higher levels of thermal discomfort and highlighted the need to consider different indicators of psychological status due to urban heat.
Lanza et al. 2023 "Heat vulnerability of Latino and Black residents in a low-income community and their recommended adaptation strategies: A qualitative study"	Austin, TX, USA, North America	Humid subtropical climate (Cfa)	Adult residents (*n* = 18) in Austin, TX, USA, from economically disadvantaged backgrounds	Semi-structured qualitative interviews	Green areas such as parks that include trees, vegetation, rivers, and lakes	Self-reported heat-related health outcomes including physical health (e.g., heat stress, fatigue, headaches, nausea, dizziness, breathing troubles, physical inactivity) and mental health and well-being (e.g., anxiety, stress, social relationships)	This study explored the heat-related health and well-being outcomes, vulnerability, and adaptation strategies for a low-income community of color in Austin, TX, USA, through semi-structured qualitative interviews. The study clarified the most common heat-related health outcomes perceived by residents, as well as those who they perceived to be the most sensitive to heat (children, people with diabetes and hypertension). Additionally, the study found that heat exposure was primarily experienced outdoors, and perceived barriers to adapting to heat included a lack of greenspace and energy cost barriers.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Li et al. 2023 "Elderly residents' uses of fragmented outdoor spaces in public housing estates in Hong Kong—Decoding causality and heat-risk exposure"	Hong Kong, China, Asia	Humid subtropical climate (Cfa)	Elderly users (n = 33,970) of open/semi-open spaces in public housing estates in Hong Kong	In-person questionnaire survey at study site	Green space such as urban parks that include greenery such as trees	Self-reported thermal perceptions/ comfort	This study explored the heat risk exposure, "fragmented" open space use, and subjective thermal perceptions of elderly residents in public housing estates in Hong Kong through physical microclimate measurements, passive observation, and questionnaire surveys. The findings demonstrated that the elderly prefer to visit open spaces near their home, and that open spaces that maintained an mPET between 30.8 and 33.1 °C provided thermal safety.
Li et al. 2022 "Summer outdoor thermal perception for the elderly in a comprehensive park of Changsha, China"	Changsha, China, Asia	Humid subtropical climate (Cfa)	Elderly (older than 60 years) visitors (n = 319) of a park in subtropic city Changsha, China	In-person questionnaire survey at study site	Urban greenery (trees, other plants) is often found in urban parks and other outdoor spaces	Self-reported thermal sensation, thermal comfort, and thermal acceptability	This study investigated the thermal perception (thermal comfort, thermal sensation, and thermal acceptability) of elderly (> 60 years) visitors to a park in the summer in a sub-tropic city, Changsha, China, through field observations, questionnaire surveys, and meteorological measurements. The results demonstrated that the neutral PET range was 21.99 to 26.97 °C, and both the thermal sensitivity and the neutral PET increased with age.
Lin et al. 2024 "Research on summer outdoor thermal comfort based on COMFA model in an urban park of Fuzhou, China"	Fuzhou, China, Asia	Humid subtropical climate (Cfa)	Visitors (n = 268) of a park in Fuzhou, China, who lived in Fuzhou for more than one year	In-person questionnaire survey	Green coverage includes trees and other plant/ vegetation coverage, found in parks	Self-reported thermal comfort	This study assessed the outdoor thermal comfort of urban park visitors in Fuzhou, China, based on the COMFA model through questionnaires and meteorological measurements. The findings demonstrated that visitors will be "unbearable" when the COMFA model reaches 177 W/m^2 or higher. The authors recommended that increasing green coverage and tree canopy can significantly improve outdoor thermal comfort.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Liu et al. 2022 "Residents' living environments, self-rated health status and perceptions of urban green space benefits"	Beijing, China, Asia	Hot summer humid continental climate (Dwa)	Residents (n = 432) of Beijing, China	Questionnaire mail-back survey	Urban green space is the "natural, semi-natural or artificial land covered by vegetative surfaces in the city". It can include urban parks, gardens, and outdoor recreational venues with vegetation, street greening, and remnant natural or ruderal vegetated enclaves	Self-rated thermal benefits associations with self-rated health status	This study evaluated the relationships between the self-rated health status and living environments on the perceptions of urban green space ecological benefits for residents of Beijing, China, through questionnaire surveys. The results demonstrated that residents living in the city and with high self-rated health status had a significantly better understanding of urban green space benefits.
Liu et al. 2022 "Modelling residential outdoor thermal sensation in hot summer cities: A case study in Chongqing, China"	Chongqing, China, Asia	Humid subtropical climate (Cwa)	Visitors (n = 375) to an urban park in Chongqing, China, on a hot summer day	In-person questionnaire survey conducted outdoors in a residential community	Trees and other vegetation	Self-reported thermal sensation, thermal acceptability, and thermal (dis)comfort	This study proposed an empirical model to predict the mean thermal sensation vote through microclimate parameters and subjective thermal sensation (questionnaire surveys). The findings demonstrated that local residents adapted to warm and hot sensations, since the model predicted neutral sensations as warm and 19.4% of warm sensations as hot. Resting beside a pond or under a tree during peak warm hours also improved thermal sensation.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Lo et al. 2022 "Space poverty driving heat stress vulnerability and the adaptive strategy of visiting urban parks"	Hong Kong, China, Asia	Humid subtropical climate (Cfa)	Tenants (n = 174) of SDU in Hong Kong and residents of Hong Kong who do not live in SDU (n = 515)	Structured in-person questionnaire surveys of SDU and non-SDU tenants	Green space includes neighborhood parks, trees, and vegetation cover	Self-reported heat-related illness (e.g., heat rash, heat cramp, heat syncope, heatstroke) and thermal comfort based on housing type	This study explored the socio-economic and heat vulnerability of tenants in SDUs in Hong Kong and associated thermal comfort practices compared to non-SDU tenants. Results demonstrated that SDU tenants were more vulnerable to urban heat than non-SDU residents and therefore had adopted more proactive thermal comfort practices less commonly adopted by non-SDU tenants (i.e., visiting urban parks).
Ma et al. 2021 "How to design comfortable open spaces for the elderly? Implications of their thermal perceptions in an urban park"	Xi'an, China, Asia	Humid subtropical climate (Cfa)	Residents over 60 years old (n = 1,417) who were conducting outdoor activities in measured spaces in winter (n = 471) and summer (n = 946)	In-person questionnaire surveys at study site	Vegetation cover in open space (e.g., trees and grass)	Self-reported thermal perceptions (comfort, preference, satisfaction), including associations with underlying health conditions	This study examined the thermal perceptions of elderly park visitors in Xi'an, China, through meteorological measurements and questionnaire surveys. After analysis, design strategies for the elderly were proposed. The results demonstrated that elderly residents with cardiovascular disease had the highest sensitivity to the outdoor thermal environment, further emphasizing the importance of providing a variety of outdoor microclimates that allow elderly residents to adapt to their thermal environment.
Maghrabi et al. 2021 "Exploring pattern of green spaces (GSs) and their impact on climatic change mitigation and adaptation strategies: Evidence from a Saudi Arabian city"	Jeddah, Saudi Arabia, Asia	Hot desert climate (BWh)	Urban green space users (n = 585) in Jeddah, Saudi Arabia	In-person questionnaire survey and semi-structured interviews were performed in parks and gardens	Green spaces are a form of green infrastructure and are a nature-based solution to climate change and include urban forests, green roofs, green walls, and parks	Self-reported heat stress and thermal comfort	This study explored the preferences for GS and the role of GS in climate change mitigation and adaptation strategies for residents in Jeddah, Saudi Arabia, through questionnaire surveys and semi-structured interviews. The results showed that GS played a crucial role in temperature regulation, reduction in heat stress, and improved outdoor thermal comfort: more than 85% of respondents agreed that GS is highly important for climate change mitigation.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Maras et al. 2014 "Investigating public places and impacts of heat stress in the city of Aachen, Germany"	Aachen, Germany, Europe	Oceanic climate (Cfb)	Visitors (n = 37) to public spaces in Aachen, Germany	On-site in-person surveys	Green spaces including vegetation such as trees and lawns	Self-reported heat perception and heat load	This study used a mixed methods approach to analyze the structural and social components of heat stress in Aachen, Germany, using spatial geo-statistical modelling, place-based survey data, biometeorological measurements, and on-site interviews. The results were combined to design a simulation, which showed that additional greenery would improve thermal comfort and reduce heat load.
Mi et al. 2020 "Outdoor thermal benchmarks and their application to climate-responsive designs of residential open spaces in a cold region of China"	Xi'an, China, Asia	Humid subtropical climate (Cfa)	Active users (n = 1,208) of an open space in Xi'an, China, in winter, spring, and summer months	In-person questionnaire survey at study site	Green space includes a variety of plant communities (e.g., trees, vines, other vegetation)	Self-reported thermal comfort and thermal acceptability	This study assessed the relationship between microclimate measurements, subjective thermal comfort, and human behavior among open space users in Xi'an, China, through physical measurements, questionnaires, and activity records. The findings revealed that PET varied between spaces, residents preferred activities in the shade in the summer, and residents could better endure "cold stress" in the winter compared to "hot stress" in the summer. The neutral PET range found was 12.4 to 26.9 °C.
Mittermüller et al. 2021 "Context-specific, user-centred: Designing urban green infrastructure to effectively mitigate urban density and heat stress"	Munich, Germany, Europe	Oceanic climate (Cfb)	Residents (n = 172) of 2 contrasting neighborhoods in Munich, Germany: (n = 87) Bahnhofsviertel and (n = 85) Messestadt	In-person questionnaire survey and semi-structured, in-depth interviews	Green spaces include green infrastructure such as trees, gardens, and other vegetation	Self-reported heat stress and thermal discomfort	This study assessed both objective data (microclimate modelling) and subjective data (questionnaire surveys and semi-structured interviews) on the interactions between density, heat, and vegetation for residents in 2 contrasting neighborhoods: (1) Bahnhofsviertel, dense and sparsely vegetated, and (2) Messestadt, less dense and ample green infrastructure. The results indicated that the amount of green infrastructure does not predict perception of urban heat; rather, it was the perceived accessibility of green space that defined its value for residents.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Nabhan et al. 2020 “Hands-on ecological restoration as a nature-based health intervention: Reciprocal restoration for people and ecosystems”	Greater Sonoran Desert, USA and Mexico, North America	Hot desert climate (BWh)	Youth ecological restoration programs in the Greater Sonoran Desert along the Arizona-Mexico border	Engagement with diverse youth in ecological restoration and education programs	Natural habitats that include diverse soil microbiota and vegetation	Heat-exacerbated diseases specific to the region such as coccidiomycosis (valley fever)	This study explored how the ecological restoration of microbiotic soil and aromatic plants reduced the urban heat island effect and therefore also reduced adverse health outcomes such as valley fever and asthma through tests of soil microbiome diversity and youth responses to restoration work. The study recommended further collaboration among restoration ecologists and ecopsychologists to better monitor the soil microbiome, plant diversity, and human health impacts of restoration projects over time; a particularly helpful next step could be cost and co-benefit estimates of restoration work across ecosystem types and human cultures.
Niu et al. 2023 “Thermal comfort influences positive emotions but not negative emotions when visiting green spaces during summer”	Chongqing, China, Asia	Humid subtropical climate (Cfa)	Visitors (n = 919) to an urban park in Chongqing, China	In-person questionnaire survey	Green spaces include urban parks and have vegetation such as trees and lawns	Self-reported thermal sensation to reflect subjective feelings and emotional well-being (e.g., pleasure, excitement, displeasure, and pain)	This study explored the effects of thermal comfort on resident emotions in 4 different green spaces in Chongqing, China, through a questionnaire and meteorological measurements. The results demonstrated that the effect of thermal comfort in green spaces on positive affect was greater than that of negative affect and when the physiological equivalent temperature increased from 20 to 55 °C, the average positive affect decreased by 7.2 scores while the negative affect did not change significantly.

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Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Oosterbroek et al. 2024 "Participatory design of urban green spaces to improve residents' health"	Maastricht, The Netherlands, Europe	Oceanic climate (Cfb)	Children (n = 25) and elderly (n = 17) residents of neighborhoods in Maastricht, The Netherlands, with low economic and health indicators	Participatory urban green space design through multiple design meetings	UGS is a type of green infrastructure, UGS-based intervention, and nature-based solution (parks, trees, lawns, shrubs, other vegetation)	Self-reported heat stress	This study developed and evaluated an approach to participatory design of UGS with children and elderly residents of Maastricht, The Netherlands, in neighborhoods with low economic and health indicators. The approach included subjective health effects of UGS designs and the use of maps to visualize UGS designs and health effects. The simulated model of the UGS designs resulted in expected subjective increases in UGS for stress reduction but little change in health benefits.
Rathmann et al. 2020 "Towards quantifying forest recreation: Exploring outdoor thermal physiology and human well-being along exemplary pathways in a central European urban forest (Augsburg, SE-Germany)"	Augsburg, Germany, Europe	Oceanic climate (Cfb)	Visitors (n = 21) of an urban forest in Augsburg, Germany	Individual physiological sensors and subjective well-being logs	Urban green space as including urban public parks, residential green space, and urban/peri-urban forests	Self-reported subjective well-being and mobile thermal physiology measurements (heart rate, inter-beat interval, blood volume pressure, galvanic skin conductance)	This study explored the relationship between urban structural types (from built up to forest) and human health effects through combining both subjective well-being data and objective human physiology data in Augsburg, Germany. The findings demonstrated that urban green space provides significant cooling and improvement of human physiology measurements (e.g., reductions in heart rate).
Rosso et al. 2024 "Tactical urban pocket parks (TUPPs) for subjective and objective multi-domain comfort enhancement"	New York City, NY, USA, North America	Humid subtropical climate (Cfa)	Users (n = 348) of pocket parks in New York City, NY, USA	In-person questionnaire surveys	Green spaces include tactical urban pocket parks, small-sized urban parks with presence of greenery, presence of furniture for users, water displays, and works of art	Self-reported thermal comfort perceptions	This study explored the effectiveness of small-sized urban "pocket parks" in New York City, NY, USA, on thermal comfort through microclimate monitoring (objective thermal comfort) and questionnaire surveys of park users (subjective thermal comfort). The results demonstrated that "Tactical Urban Pocket Parks" had a greater significant improvement of subjective thermal comfort compared to objective thermal comfort.

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Sousa-Silva and Zanocco 2024 "Assessing public attitudes towards urban green spaces as a heat adaptation strategy: Insights from Germany"	Germany, Europe	Oceanic climate (Cfb)	German adult residents (*n* = 2,253) ages 18 years or older	Online survey conducted by YouGov, "an international market and public opinion research company"	Urban green space defined as "areas of vegetation in public and private areas, including parks, gardens, lawns, tree alleys, green roofs, and cemeteries"	Self-reported experiences with green space as an adaptation measure to reduce heat stress and other adverse heat-related impacts	This study assessed the attitudes of German adults after the summer of 2022 on their perceived benefits of green space and their perspectives of green space as an adaptation measure against heat stress. Findings demonstrated overall positive associations with green space, but fewer than 20% frequented them on warm days, suggesting that the cooling potential of green space may be less understood.
Wong et al. 2017 "Urban heat island experience, control measures and health impact: A survey among working community in the city of Kuala Lumpur"	Kuala Lumpur, Malaysia, Asia	Tropical rainforest (Af)	People (*n* = 1,050) working in manufacturing and service sectors in 3 areas in Greater Kuala Lumpur, Malaysia (Mount Kiara, Jalan Raja Chulan, and Setia Alam)	Face-to-face roadside structured questionnaires	Vegetation cover (green areas) that includes green roofs, green walls, gardens, green space, parks, and trees	Self-reported adverse health experiences of urban heat island effect (physical health experience [heat exhaustion, heat stroke, etc.], psychological [depression, anxiety, etc.], and social [skip work, reduce outdoor activities, etc.])	This study assessed the health impacts of the UHI effect on workers in Kuala Lumpur, Malaysia. The findings demonstrated that greater adverse health effects of UHI were associated with low measures to reduce UHI effects (including green vegetation, shaded lanes in active transport, and lack of appropriate building materials).
Wong et al. 2024 "Visiting urban green space as a climate-change adaptation strategy: Exploring push factors in a push-pull framework"	Hong Kong, China, Asia	Humid subtropical climate (Cfa)	Individuals aged 15 or older (*n* = 483) from local Hong Kong households	Questionnaire survey	Urban green space types such as urban parks include vegetation coverage like trees and grass	Self-reported personal health impacts due to heat, including heat syncope and heat stress	This study examined the push and pull factors for UGS for residents in Hong Kong through a questionnaire survey of park users. The results indicated that health concerns, proximity to urban green space, and respondent age were significant predictors of UGS use. There was also notable interdependence between push and pull factors, such as the relationship between UGS visits and indoor living conditions as a push factor, and cooling as a pull factor.

Table 1 continued on next page

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Wu et al. 2024 "Investigating the potential of street trees in mitigating pedestrian thermal stress during heatwaves conditions: An empirical study in Guangzhou"	Guangzhou, China, Asia	Humid subtropical climate (Cfa)	Male university students (n = 15) who had lived in Guangzhou, China, for over a year	Questionnaire survey during thermal walk experiment on a hot day	Urban greenery includes street trees and other plants	Self-reported thermal sensation and comfort	This study used a thermal walking experiment and questionnaire survey to assess the physical thermal stress of residents of Guangzhou, China, during their commutes. Additionally, the study specifically evaluated the heat tolerance of street trees and their impact on resident experiences. The results demonstrated that street trees affect the intensity, sequency, and duration of their exposure to heat; pedestrians showed higher heat tolerance when the cooling effect of trees surpassed 6 °C (thermal comfort vote > 1 and thermal acceptance vote > –0.01).
Yung et al. 2019 "Thermal perceptions of the elderly, use patterns and satisfaction with open space"	Hong Kong, China, Asia	Humid subtropical climate (Cfa)	Elderly residents ages 65 or older (n = 485) using community open spaces in Hong Kong in summer (n = 219) and winter (n = 235)	In-person questionnaire survey at study site	Urban greenery such as tree canopy and other plants	Self-reported thermal perceptions (comfort, sensation, acceptability)	This study explored the thermal perceptions of elderly residents in Hong Kong when using open space in summer and winter on individual, physical, social, and psychological factors through questionnaire surveys and meteorological measurements. The results demonstrated the varying factors that influence the elderly's thermal perceptions in both winter and summer, although they stressed the importance of paying particular attention to thermal comfort in outdoor spaces on hot days.
Zhang et al. 2020 "Outdoor thermal comfort of urban park—A case study"	Chengdu, China, Asia	Humid subtropical climate (Cwa)	Residents (n = 419) of Chengdu, China, visiting a park in the summer	Questionnaire survey at the chosen park (study site)	Urban green spaces include public parks with vegetation coverage (trees, other plants)	Self-reported thermal comfort	This study assessed the outdoor thermal comfort in an urban park in Chengdu, China, through meteorological monitoring and a questionnaire survey of Chengdu residents. The study found multiple results, including that different types of urban park landscapes have different thermal comfort scores and air temperature is the most important factor affecting outdoor thermal comfort.

Table 1. Continued.

Author/year and title	Location	Köppen climate classification	Definition of community engaged	Method of community engagement	Urban greening description or definition	Heat-related health outcome	Summary of findings
Zhang et al. 2023 "Perceptions of the health risk from hot days and the cooling effect of urban green spaces: A case study in Xi'an, China"	Xi'an, China, Asia	Humid subtropical climate (Cfa)	Residents (n = 325) visiting urban parks in Xi'an City, China, on hot days	Questionnaire survey with close- and open-ended questions	Green space as a natural-based solution to climate mitigation and includes street trees and parks	Self-reported health risk and physical discomfort on hot days (sleep disorders, respiratory discomfort, cardiovascular and cerebrovascular complications, digestive system diseases, sunburn, sunstroke)	This study explored the perceptions of residents in Xi'an, China, on the relationship between the environment, heat-mitigation measures, and heat-related health risk through questionnaire surveys. The study found that 30.16% of respondents were under a huge health risk on hot days and 44.92% of respondents sought medical treatment due to hot days. Women were 18.52× more likely to suffer health threats than men. The study recommended the optimization of landscape patterns of green infrastructure to prevent heat health risks.

Table 2. Community engagement methods.

Engagement method	Count	Percent of 46
Survey	39	85%
In-person survey	33	72%
Online survey	3	7%
Mail-back survey	4	9%
Telephone survey	2	4%
Semi-structured interview	5	11%
Physiological measurements	1	2%
Community co-creation	4	9%
Community educational events	3	7%
Ecological stewardship events	1	2%
Participatory planning	3	7%

Table 3. Urban greening terms.

Term	Count	Percent of 46
Urban greening/green space/ green area	38	83%
Urban forest/trees	40	87%
Green infrastructure	15	33%
Intervention	10	22%
Nature/natural-based solutions	8	17%
Vegetation	14	30%

Table 4. Heat-related health outcomes.

Heat-related health outcomes	Count	Percent of 46
Self-reported/subjective	43	93%
Objective	5	11%
Morbidity and mortality rates	2	4%
Physiological measurements	1	2%
Hospitalization/ambulance	2	4%

Table 5. Evaluation of eligible papers. UHIR (urban heat island reduction); PP (pocket parks); IP (interim plazas); POPs (privately owned public spaces); GIS (geographic information systems).

Criteria	Number of papers that met criteria	Select examples
Identification of urban greening/forestry/other nature-based solution for climate change-amplified heat mitigation with quantifiable benefits	40	Hopkins et al. 2022 (Houston, TX, USA): Expert stakeholders (landscape architects, state foresters, local tree planting nonprofits, and tree enthusiasts) identified native tree species from the City of Houston Tree and Shrub Ordinance based on climate-related ecosystem services including carbon sequestration, air pollution absorption, water absorption, and heat island reduction. Trees were ranked based on measures such as canopy size for UHIR effects.
		Maghrabi et al. 2021 (Jeddah, Saudia Arabia): This study assessed resident perceptions of the role of green space in climate change mitigation. The study found that 85% of the residents surveyed believe that green spaces play a "crucial" role in climate change mitigation strategies, including temperature regulation and reduction in the urban heat island effect.
		Rosso et al. 2024 (New York City, NY, USA): This study compared the heat mitigation benefits of different "tactical urban pocket parks", including (a) PP, which have greenery, water bodies/fountains, varied furniture, shade, and are separated from the street; (b) IP, which are plazas that can be eventually transformed into permanent plazas and which have different pavement or color material than the street, furniture, lighting, artwork, and some green cover; and (c) POPs, which are "outdoor and indoor spaces provided for public enjoyment by private owners" with shaded and sunny areas visible from the street. The air temperature was found to be cooler in all parks taken together, but heat mitigation was found to be higher in PPs and POPs. IPs instead experienced higher temperatures than the surrounding streets in general.

Table 5. Continued.

Criteria	Number of papers that met criteria	Select examples
Association between objective heat-related health outcomes/health equity and urban greening interventions	5	Hopkins et al. 2022 (Houston, TX, USA): Using GIS, the health department stakeholders created maps depicting areas of Houston in the upper quartile for rate of cardiac arrest and asthma attacks; the upper quartile of the proportion of census tract that flooded during hurricane Harvey; the upper quartile for air pollutants; and the upper quartile for temperature. The result of the mapping identified locations in the city to be selected as tree planting locations due to environmental justice and health equity need.
		Rathmann et al. 2020 (Augsburg, Germany): This study explored the human well-being cooling benefits of urban greening using both subjective well-being logs and objective human physiological data (i.e., blood pressure readings) in an urban forest in Germany. The result of this study demonstrated significant positive effects of urban greening on human physiological measures (e.g., reduction in heart rate).
		Huanchun et al. 2021 (Beijing, China): This study conducted a simulation of potential green space in Beijing to optimize the reduction of the impact of the urban heat island effect on respiratory disease, cardiovascular disease, and emotional health. The resulting planning strategy for green space recommended a layout of "three vertical and four horizontal corridors encompassed in one ring".
Sustainable and ongoing community engagement and/or community co-creation	5	Hopkins et al. 2022 (Houston, TX, USA): First, a "leading environmental non-profit group" engaged the Houston Health Department to discuss native tree species and associated benefits with public health, working together to choose locations of interest. Next, additional partners were engaged across multiple other sectors, including other environmental groups, businesses, and industry partners. This engagement was done through "a series of meetings, a luncheon, lectures, webinars, video and in-person forums, and on-site tree species demonstrations".
		Nabhan et al. 2020 (Great Sonoran Desert, USA/Mexico): This study demonstrated examples of culturally diverse youth programs focused on ecological restoration or urban regreening activities. These programs offered opportunities for ecopsychology and other health/ecology researchers to work with youth and better evaluate the impacts of nature-based interventions on human and ecosystem health.
		Oosterbroek et al. 2024 (Maastricht, The Netherlands): This study provided an example of participatory design of urban green space in neighborhoods with low economic and health indicator scores through engagement with older-aged and youth residents. The process included choosing a set of health effects to assess and how to assess them, orienting community members on a neighborhood walk, conducting a first design session with the community, iterating with experts and participant self-assessments, and finally reporting the results to local decision makers.

This paper was limited in that it was a scoping review, which assesses broad themes or gaps in the literature, resulting in a less analytical description of the literature, compared to a systematic review. To include research across disciplines, we had to have broad inclusion criteria with multiple possibilities for inclusion, which may have introduced bias within our screening. Furthermore, while we recognize the expanse of literature in each respective field, our goal was not to be necessarily comprehensive but rather to evaluate the methods and research practices that combine urban greening interventions with community engagement principles to prevent heat-related health effects.

CONCLUSIONS

As climate change threats increase, it becomes increasingly important to protect those most vulnerable to extreme heat events. Urban greening interventions have proven to be a sustainable and effective solution to cooling, yet there are few succinct frameworks that guide how to design and maintain urban green spaces with long-term community collaboration and measurable community heat-related health outcomes. Our study aims to inform urban greening researchers on the landscape of the literature to support transdisciplinary, health-focused urban greening.

Our findings therefore come at an urgent time, as climate change risks increase and as urban greening and heat-related public health policies become a priority around the world. In the United States alone, the Inflation Reduction Act invested $1.5 billion to support urban forest expansion, planning, and management, particularly for disadvantaged communities (USDA Forest Service 2023). Multiple cities in the United States have also recently passed legislation that codifies the expansion of the urban forest (City of Chicago 2009; City of Syracuse 2020; Urban Forestry Division 2022; Kiel 2023). As other cities establish similar plans and receive funding for research and implementation, it is even more necessary for planners to have a framework grounded in health equity goals, community-dependent designs, and transdisciplinary collaboration. We hope our discussion on the intersection of urban greening, heat-related health, and communities can help to inform planners so that the cooling health benefits of urban greening can be realized for all.

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Résumé. Les changements climatiques ont amplifié l'impact des épisodes de chaleur extrême (ECE), exacerbant la morbidité et la mortalité liées aux canicules, en particulier dans les villes en raison de l'effet des îlots de chaleur urbains. Bien qu'il existe une solution à long terme pour atténuer la chaleur grâce au verdissement urbain, on en sait moins sur la manière de mettre en œuvre un plan de végétalisation urbaine conçu conjointement par les membres de la communauté et s'attaquant aux problèmes de santé liés à la chaleur. Afin d'examiner l'état actuel des interventions de verdissement urbain axées sur les communautés et l'atténuation de la chaleur, nous avons réalisé une étude exploratoire d'articles portant sur le lien entre la végétalisation urbaine/la foresterie, les impacts sur la santé liés aux canicules et l'engagement communautaire. Nous avons ensuite évalué 46 articles admissibles à l'aide d'un cadre conceptuel fondé sur la littérature comportant les critères suivants: (1) identification des espaces verts /arbres urbains pour l'atténuation de la chaleur amplifiée par les changements climatiques avec des avantages quantifiables; (2) association entre des résultats sur la santé objectifs liés à la chaleur/l'équité en matière de santé et le modèle d'intervention en végétalisation urbaine; et (3) engagement durable et continu de la communauté et/ou cocréation communautaire. Nous avons constaté de nombreuses différences entre les méthodes évaluées. La plupart des articles ne contenaient pas de données objectives sur les impacts de la chaleur sur la santé et se concentraient plutôt sur les mesures subjectives du confort thermique et du stress dû à la chaleur. En outre, presque tous les articles concernaient des méthodes d'engagement communautaire ponctuelles, telles que des enquêtes ou des entrevues, pour informer la communauté des recommandations en matière de végétalisation urbaine ou des résultats de la recherche. Nos résultats ont des implications utiles pour la prise de décision en matière de verdissement urbain et soulignent l'importance de la coopération transdisciplinaire et de l'engagement communautaire à long terme, afin qu'une intervention équitable et contextuelle en matière de végétalisation urbaine et de santé puisse être efficacement coproduite par les urbanistes, les responsables de la santé publique et les membres de la communauté.

Zusammenfassung. Der Klimawandel hat die Auswirkungen extremer Hitzeereignisse (EHE) verstärkt und die hitzebedingte Morbidität und Mortalität verschlimmert, insbesondere in Städten infolge des städtischen Wärmeinseleffekts. Zwar gibt es mit der Stadtbegrünung eine langfristige Lösung zur Abschwächung der Hitze, doch ist weniger darüber bekannt, wie ein von Gemeindemitgliedern mitgestalteter Plan zur Stadtbegrünung umgesetzt werden kann, der hitzebedingte gesundheitliche Folgen berücksichtigt. Um den aktuellen Stand der städtischen Begrünungsmaßnahmen zu untersuchen, die sich auf Gemeinden und Hitzeschutz konzentrieren, haben wir eine Übersichtsarbeit zu den Themen städtische Begrünung/Forstwirtschaft, hitzebedingte Gesundheitsauswirkungen und Engagement der Gemeinden durchgeführt. Anschließend bewerteten wir 46 in Frage kommende Arbeiten anhand eines konzeptionellen Rahmens, der sich auf die Literatur stützt und die folgenden Kriterien berücksichtigt: (1) Identifizierung von städtischen Grünflächen/Bäumen zur Abschwächung der durch den Klimawandel verstärkten Hitze mit quantifizierbarem Nutzen; (2) Zusammenhang zwischen objektiven hitzebedingten Gesundheitsergebnissen/Gesundheitsgerechtigkeit und der Gestaltung von städtischen Begrünungsmaßnahmen; und (3) nachhaltiges und fortlaufendes Engagement in der Gemeinschaft und/oder Mitgestaltung der Gemeinschaft. Wir fanden mehrere Unterschiede zwischen den Studienmethoden. Die meisten Arbeiten enthielten keine objektiven Daten zu hitzebedingten Gesundheitsfolgen und konzentrierten sich stattdessen auf subjektive Messungen des thermischen Komforts/Hitzestresses. Darüber hinaus nutzten fast alle Arbeiten einmalige Methoden der Bürgerbeteiligung wie Umfragen oder Interviews, um Empfehlungen zur Stadtbegrünung oder Studienergebnisse zu ermitteln. Unsere Ergebnisse haben nützliche Implikationen für die Entscheidungsfindung bei der Stadtbegrünung und unterstreichen die Bedeutung einer fachübergreifenden Zusammenarbeit und eines langfristigen Engagements in der Gemeinde, damit eine gerechte, kontextabhängige Stadtbegrünung und Gesundheitsintervention von Stadtplanern, Gesundheitsbehörden und Gemeindemitgliedern effektiv gemeinsam entwickelt werden kann.

Resumen. El cambio climático ha amplificado los efectos de los Eventos de Calor Extremo (EHE), exacerbando la morbilidad y mortalidad relacionadas con el calor, particularmente en las ciudades debido al efecto de isla de calor urbana. Si bien existe una solución a largo plazo para mitigar el calor mediante el reverdecimiento urbano, se sabe menos sobre cómo implementar un plan de reverdecimiento urbano co-diseñado por miembros de la comunidad que aborde los efectos sanitarios del calor. Para examinar el estado actual de las intervenciones de reverdecimiento urbano centradas en las comunidades y la mitigación del calor, realizamos una revisión exploratoria de documentos en el nexo del reverdecimiento urbano/silvicultura, los efectos sanitarios del calor y la participación comunitaria. Luego evaluamos 46 documentos elegibles utilizando un marco conceptual informado por la literatura con los siguientes criterios: (1) identificación de espacios verdes urbanos/árboles para la mitigación del calor amplificado por el cambio climático con beneficios cuantificables; (2) asociación entre efectos sanitarios objetivos del calor en relación con el acceso a la salud, y su intervención en el diseño de infraestructura verde urbana; y (3) participación comunitaria sostenible y continua y/o co-creación comunitaria. Encontramos múltiples diferencias entre los métodos de estudio. La mayoría de los artículos carecían de datos objetivos sobre los resultados sanitarios relacionados con el calor y, en cambio, se centraban en medidas subjetivas de confort térmico/estrés térmico. Además, casi todos los artículos utilizaron métodos puntuales de participación comunitaria, como encuestas o entrevistas, para fundamentar las recomendaciones sobre áreas verdes urbanas o los hallazgos de los estudios. Nuestros hallazgos tienen implicaciones útiles para la toma de decisiones sobre áreas verdes urbanas, lo que enfatiza la importancia de la cooperación transdisciplinaria y la participación comunitaria a largo plazo, de modo que los urbanistas, las autoridades sanitarias y los miembros de la comunidad puedan coproducir eficazmente una intervención equitativa y adaptada al contexto en áreas verdes urbanas y la salud.