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Building Community Resillience to Extreme Heat: Lessons Learned from Spokane, WA Community Conversations

Anna Reed
University of Washington

Brian G. Henning
Gonzaga University, henning@gonzaga.edu

Marina Cortes Espinosa
University of Washington

Hannah McKinley
University of Washington

Tania Busch Isaksen
University of Washington

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Building community resilience to extreme heat: Lessons learned from Spokane, WA community conversations

A Reed[1,*], B Henning[2], M Cortes Espinosa[1], H McKinley[1] and T Busch Isaksen[1]

[1] Department of Environmental and Occupational Health Sciences, School of Public Health, University of Washington, Seattle, WA, United States of America
[2] Institute for Climate, Water, and the Environment, Gonzaga University, Spokane, WA, United States of America
* Author to whom any correspondence should be addressed.

E-mail: areed5@uw.edu

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Abstract

Heat is the primary cause of weather-related mortality in the United States. The 2021 Northwest heat dome highlighted this susceptibility. In Washington State, 159 excess deaths were attributed to the 7-day period of unprecedented extreme heat between June 26th and July 2nd. This impact was felt even in some of the more acclimatized parts of the state, like Spokane County, where 19 heat-related deaths were reported. As climate change increases the frequency, duration, and intensity of extreme heat events, creating and sustaining heat-resilient communities has become an urgent public health priority. On 6 June 2023, Gonzaga University, in partnership with the University of Washington, hosted the Spokane Extreme Heat Risk Intervention Stakeholder Synthesis Symposium. The goals of the symposium were to debrief from recent heat events, identify extreme heat risk reduction interventions used in the region, and characterize remaining practice-relevant research priorities. The symposium convened 45 stakeholders including representatives from local and state agencies, academia, and community-based and Tribal organizations. Symposium participants engaged in small group discussions using the World Café Method^{TM}. Notes from each discussion were coded using a content analysis approach. Symposium participants identified strengths, barriers to heat resilience, and solutions to reduce risk throughout the Spokane community. We present these findings by practice topic, including risk communication, intervention, collaboration, policy, and research. Additionally, we utilize the socio-ecological model as a conceptual framework to illustrate the complex interplay of factors that govern an individual's experience of, and ability to respond to, extreme heat events. Given extreme heat's impact on global public health, the methods used to increase community resilience in Spokane, WA, USA could be used by other communities worldwide to increase their own heat-resilience.

1. Introduction

Global ambient temperatures have increased between 0.8 °C and 1.3 °C compared to the pre-industrial period, primarily due to human activity [1]. According to the Intergovernmental Panel on Climate Change sixth assessment report, global ambient temperature will continue to rise until at least mid-century, with warming exceeding 1.5 °C–2 °C by the end of the 21st century unless significant emissions reductions are achieved. As a result, extreme heat events are expected to increase in frequency, duration, and intensity. Extreme heat is already the primary cause of weather-related mortality in the United States [2] and has been demonstrated to increase morbidity from cardiovascular and respiratory diseases, infectious and metabolic disease, mental health and neurological disorders, and occupational injuries and illnesses [3]. Older adults [4, 5], young children [6], pregnant people [7], and those with pre-existing conditions [6] are at increased

Table 1. Symposium participants' organization type[a].

Organization	N	%
Academia	13	23.6
Local public health agency (e.g. county health department)	6	10.9
State public health agency	3	5.5
Non-public health local government agency (e.g. city government)	10	18.2
Non-public health state government agency	1	1.8
Federal government	1	1.8
Tribal organization	2	3.6
Non-governmental organization	14	25.5
Medical provider	3	5.5
Media	1	1.8
Private sector	1	1.8
Total	55	100

[a] Includes event speakers, some of whom participated in the World Café, and the six University of Washington World Café facilitators.

risk of developing heat illness due to physiology, while outdoor workers [8, 9] and precariously housed individuals [10] are at increased risk due to exposure.

While Washington State is often associated with a temperate climate, extreme heat plays a significant role in natural hazard-related mortality [11] and morbidity [12]. The 2021 heat dome that struck the Northwest highlighted this susceptibility. One-hundred fifty-nine excess deaths have been attributed to the 7-day period of unprecedented extreme heat between June 26th and July 2nd [13]. Nineteen of these deaths occurred in Spokane County, despite it being one of the more acclimatized regions of the state (average age 59.5, range: 26–81) [14]. Arnold *et al* found the odds of mortality in Spokane County increase between 2% and 6% on a 99th percentile day compared to a 50th percentile day, depending on the climate zone within the county [11].

To engage regional stakeholders in dialogue around the 2021 Heat Dome and extreme heat risk reduction, Gonzaga University, in partnership with the University of Washington, hosted the Spokane Extreme Heat Risk Intervention Stakeholder Synthesis Symposium in Spokane, WA on 6 June 2023. The goals of the symposium were to debrief from recent heat events, identify existing extreme heat risk reduction interventions used in the region, and characterize remaining practice-relevant research priorities. Further, the symposium sought to elucidate perceived system barriers and facilitators to implementing heat-exposure reduction interventions for at-risk groups. The purpose of this paper is twofold: illustrate a community engagement method that communities, worldwide, can replicate to build heat resilience; and describe heat exposure risk reduction strategies specific to Inland Northwest communities.

2. Methods

The symposium was coordinated by a team of Gonzaga University and University of Washington faculty, staff, and students. Symposium organizers from Gonzaga University's Institute for Climate, Water, and the Environment (Climate Institute) invited a diverse representation of community-based organizations, government agencies, academia, Tribal organizations, and medical providers that were actively engaged in heat-exposure reduction and response activities during the 2021 Heat Dome. Additional partner organizations that would add significant perspectives/action in building resilience within Spokane's vulnerable communities were added to the invite list. Of 122 invitees, 55 regional stakeholders (including the organizing team and facilitators/notetakers) representing over 35 agencies, organizations, communities, and Tribal organizations attended the symposium (table 1).

The symposium began with presentations on the health risks of extreme heat exposure, the connection between extreme heat and climate change, and preliminary results of a survey on heat perceptions among Spokane residents, conducted in 2022. Following these presentations, participants heard from a panel of local practitioners who discussed their experiences of the 2021 Heat Dome and needs for future extreme heat events. The final symposium activity provided participants the opportunity to engage in small group discussions to reflect on the 2021 Heat Dome and share their knowledge and expertise related to heat-exposure reduction and response. These discussions were facilitated using the 'World Café Method,' a technique designed to facilitate large group dialogue where participants are invited to share diverse perspectives and connect with one another [15]. Six tables were assigned one of four populations that the literature has shown are at increased risk during extreme heat events. The first two populations are at risk due to physiological factors: (1) underlying health conditions (1 table) and (2) age-related (1 table). The second two populations are at risk due to exposure: (3) work/recreation (2 tables) and (4) precariously

housed (2 tables). Participants engaged in four 20-minute group discussions. At the end of each 20-minute discussion, participants rotated to form new groups at different tables. Each 20-minute discussion focused on a different overarching question:

(1) Who is uniquely susceptible to extreme heat in this community? Why?
(2) How can we effectively communicate risk to our susceptible populations?
(3) What activities/interventions have been used to reduce health risks during previous extreme heat events?
(4) How can collaboration and/or research improve preparedness and response to future extreme heat events?

Each table had a facilitator and notetaker. Facilitators were trained on the use of a discussion guide that included prompts and additional questions to promote a robust discussion. A room facilitator described the World Café Methods and goals to participants before the first round.

Facilitators and table participants worked in tandem to capture the conversation on a flip chart at each table. Table participants were encouraged to document their ideas on post-it notes that were placed on the flip chart. Facilitators had the option to add additional post-it notes and write and draw directly on the flip chart to further illustrate the table's discussion. Each table setting included a paper placemat and writing utensils for participants to organize their ideas and/or process the discussion in a visual manner.

Following the last round of discussion, facilitators reviewed the flip chart from their table to summarize key points made during each round. This summary was presented to participants who had the opportunity to rank their priority areas for each population on a voting sheet. After the symposium, facilitators reviewed and edited notes for accuracy and completeness.

Conventional qualitative content analysis methods were used to identify and synthesize successful heat risk reduction interventions, barriers and facilitators to heat resilience, and research needs documented in the notes [16, 17]. Codes were developed inductively by two members of the research team, who reviewed the notes to identify emerging themes. The codebook, including code definitions, was reviewed by a third member of the research team and further refined to ensure clarity and consistency. Two members of the research team co-coded two sets of notes using a consensus-building approach to ensure reliability of the codebook. The remaining four sets of notes were coded by one member of the research team. All coding was conducted using Dedoose (Version 9.0.107), a secure online qualitative data analysis platform.

3. Results and Discussion

During the first round of discussion, participants were asked to consider who is uniquely susceptible to extreme heat and why. Table discussions reinforced what has previously been established in heat risk literature; in addition to those who are at increased risk due to physiology (e.g. children, older adults, individuals with underlying health conditions) or exposure (e.g. outdoor workers), factors such as housing and economic status, race, and neighborhood can further modify and compound individual risk [18]. This discussion highlighted the structural factors that create disparities among Spokane community members' resilience to extreme heat events. These factors are consistent with the social determinants of health (SDOH), the framework that suggests that the conditions in which people are born, live, work, and play affect their health [19].

Symposium participants highlighted numerous community strengths—organizations, programs, and relationships—that support Spokane residents in preparing for, coping with, and recovering from extreme heat events. In addition, participants identified barriers to the implementation and uptake of heat risk reduction strategies, such as the complexity of communicating heat risk, lack of funding, and the high cost of utilities. Participants also discussed solutions, such as developing PSAs featuring local stories, facilitating neighborhood canvassing to identify at-risk residents, and implementing a centralized resource map for Spokane residents. We present these findings—strengths, barriers, and solutions—by topic areas identified during the coding process: risk communication, interventions, collaboration, policy, and research (table 2).

3.1. Risk Communication

Participants emphasized the importance of tailoring heat risk communications to meet the needs of the intended audience. They noted that there are five living generations, meaning there is a broad spectrum of technology literacy and access, and preferred information sources, across the population. In addition to generational differences, other factors such as English proficiency, housing and health status, trust in authority, and community connectedness were highlighted by participants as impacting community members' ability to access and internalize heat risk communications. Participants called for online, print, and in-person communications and described the importance of 'meeting people where they are' to deliver

Table 2. Strengths, barriers, and solutions to community heat resilience, by topic area.

Risk Communication	
Strengths	Community-based organizations such as meals on wheels (MoW) are seen as trusted messengers by clients; MoW utilizes appropriate communication mode (print flyers) for the organization's older adult client demographic
	Local TV news is easily accessible; meteorologists are widely trusted spokane's spanish language radio station
Barriers	There is a broad spectrum of technology literacy and access, and preferred information sources, across five living generations
	The complexity of communicating heat risk (i.e. risk thresholds vary on many physiological and exposure factors)
	Lack of access to resources to act in response to risk communications language
	Trust in authority
	Noise fog
Solutions	Meet people where they are (e.g. religious institutions, senior centers, street outreach) use multi-modal communications tailored to audience (e.g. online, print, in-person) avoid 'doom and gloom' messaging; include protective actions and resources develop heat plans with contingencies for canceling large events
	Develop PSAs featuring stories of local extreme heat impacts partner with trusted messengers and pay them for their work design an early warning system
	Use a color-coded heat risk index
	Streamline the risk messaging increase funding
Interventions	
Strengths	Utility assistance for low-income and older adults
	Local energy company, Avista, provides battery backup for customers who rely on medical equipment
	Local service providers, including MoW and CARES, were highlighted for their strong community relationships and effective service provision
Barriers	The high cost of utilities, weatherization, and A/C installation
	The burden of weatherization and A/C installation often falls on the tenant, but requires their landlord's permission
	A power imbalance between landlords and tenants
	Administrative burden related to applying for and maintaining utility assistance
	Societal roles and cultural norms (e.g. desire to appear tough at work) can prevent individuals from resting and hydrating
	Piece-rate workers may face added pressure to avoid work stoppages
	Stigma related to asking for help or receiving government support
	Fear of authority prevents some individuals from utilizing cooling centers and the healthcare system
Solutions	Develop and implement educational interventions in schools and workplaces to raise awareness of heat health risks and to normalize protective behaviors
	Design cooling centers that are fun, dignified, and welcoming and clearly communicate cooling center offerings (e.g. if pets are permitted)
	Prioritize intentional community building in the wake of the COVID-19 pandemic (e.g. intergenerational community events with food)
	Implement neighborhood canvassing to assess household risk and encourage neighbor buddy systems
	Increase funding to expand access to existing interventions (e.g. utility assistance) and implement new interventions (e.g. workplace training)
Collaboration	
Strengths	Avista partners with local organizations, including MoW, to disseminate resources and to develop and pilot programs
	Spokane public library partners with peer spokane to offer peer support services
Barriers	Many heat risk reduction efforts are currently siloed

(Continued.)

Table 2. (Continued.)

Risk Communication	
Solutions	Establish a convener to bring organizations and agencies together surrounding heat health risk reduction strategies
	Increase collaboration across sectors to streamline risk communication and increase resource sharing
	Invest in partnerships with trusted messengers to disseminate heat risk communications
	Establish public–private partnerships with social media companies to override algorithms and geo-target heat risk communications
	Develop and implement a centralized resource map, including cooling center locations, services, and operating hours; funding is needed to ensure map is updated regularly
	Establish partnerships in advance of heat events
Policy	
Strengths	The spocanopy program seeks to increase spokane's urban tree canopy splash pads at city parks City cooling centers Spokane transit authority' fare exemption program offers free rides to cooling centers in temperatures above 95°F to individuals without fare
Barriers	Lack of affordable housing systemic racism
	Disparities in the built environment, including urban heat islands gentrification, which disrupts social connection
	Harmful policies (e.g. encampment sweeps) and a lack of resources for people experiencing homelessness
	Tactics designed to deter homeless population from utilizing community resources impact everyone (e.g. lack of functioning water fountains)
	Lack of political will to invest in climate adaptation and mitigation policy
Solutions	Fund extreme heat task force to lead proactive government response Develop and implement city and county heat action plans
	Update regulations and code enforcement to protect workers, precariously housed populations, and students
	Implement rent control to reduce housing instability Prioritize participatory policymaking
	Pursue additional methods of increasing city's urban tree canopy, such as through development requirements
	Increase access to resources (e.g. lifejackets at city beaches)
Research	
Needs	Prioritize community-based participatory research methods Include housing stability/status in future research
	Evaluate senior housing quality in the region
	Conduct additional homeless Point-in-Time counts during a warmer month
	Characterize specific vulnerabilities of precariously housed populations to extreme heat
	Increase understanding of how heat health risk communication is received across the population; which messengers are trusted?
	Evaluate whether wetbulb globe temperature could be useful tool to help general population understand heat risk and make informed decisions
	Describe financial impacts of climate change at local level characterize local climate mitigation opportunities

information (e.g. at religious institutions, senior centers, or through street outreach). They emphasized the importance of partnering with trusted messengers to disseminate heat risk communications, especially to at-risk populations, and that trusted messengers should be paid for their work. These findings are consistent with existing hazard risk communication literature, which suggests that the messenger is as important as the communication mode [20, 21].

Participants discussed the importance of streamlined and consistent messaging across agencies, even if the mode or method varies to appeal to the intended audience. They noted that seeing different messages, including misinformation, from a variety of sources can contribute to 'noise fog.' Additionally, participants warned against 'doom and gloom' messaging (i.e. messages with an emphasis on risk without

recommendations for protective actions or resources) and urged agencies and organizations to be mindful of the mental health impacts of their communications.

Participants acknowledged that communicating the complexity of heat risk (i.e. risk thresholds vary on many physiological and exposure factors) adds to the challenge of effective risk communication. Participants emphasized the need for a color-coded heat risk index, like the Air Quality Index, that would address the compounding factors that determine risk (e.g. humidity, underlying health conditions, etc). Other suggestions included developing heat plans with contingencies for canceling large events (e.g. outdoor concerts, youth sports tournaments), using PSAs featuring stories of local extreme heat impacts, and developing an early warning system. Participants agreed that effective risk communication requires sufficient funding.

Meals on wheels (MoW) was highlighted by participants as an example of a local organization whose volunteers are considered trusted messengers by the older adults who receive meals through the organization. MoW delivers print newsletters with their meals, which participants agreed was an appropriate communication mode for the MoW client demographic. Other examples of successful risk communication shared by participants included Spokane's Spanish language radio station and local TV news, which is easily accessible and whose meteorologists are seen as widely trusted across the population.

Participants noted that risk communication is ineffective when people do not have the resources to protect themselves and their families and, as such, must be paired with the implementation of effective interventions.

3.2. Interventions

Participants highlighted the high cost of utilities, weatherization, and A/C installation as barriers to extreme heat resilience, especially among low-income residents and renters. They discussed how the burden of weatherization and A/C installation often falls on the tenant but requires landlord approval. Participants noted the power imbalance between landlords and tenants, a factor that may dissuade tenants from making such requests. One participant commented, 'a renter may not be able to ask the landlord for more than basics, in fear of losing their housing.' Several local organizations and government agencies offer utility assistance to low-income and older adults. In addition, Avista, the energy company that provides electric and natural gas service to customers across eastern Washington, including Spokane, is piloting a program to provide battery backup for customers who rely on medical equipment. While participants applauded these efforts and desired increased funding for utility assistance, they also cited administrative burden as a barrier to uptake, particularly for older adults who lacked confidence with and/or access to technology.

Societal roles and cultural norms were noted as additional barriers to intervention uptake. Participants cited the desire to appear tough or capable at work, or as an athlete, as reasons why individuals may be reluctant to take breaks to rest and hydrate. Piece-rate workers may face added pressure to earn money and provide for their families, further incentivizing them to work through dangerous conditions. Participants suggested developing and implementing educational interventions in workplaces and schools to raise awareness about heat health risks (including signs and symptoms of heat illness, who is most at risk, and how to cool down) and to normalize protective behaviors. Stigma related to asking for help or receiving government support was discussed as a barrier to cooling center use, as was fear of authority. Participants noted that undocumented individuals may be less likely to seek assistance at cooling centers or from medical professionals. Participants highlighted the importance of making cooling centers fun, dignified, and welcoming, such as by offering activities relevant to different ages. They emphasized the importance of clearly communicating cooling center offerings (e.g. if pets are allowed) so that community members know what to expect. One participant commented, 'it all comes back to communication. How can you make it sound fun, inviting, and [that] all are welcome.'

Participants discussed the importance of community connectedness to heat resilience, especially at the neighborhood level. This finding is consistent with existing extreme heat and disaster literature. Previous studies have found that social connections, a form of social capital, can facilitate awareness of and access to resources and can lower isolation and adverse mental health impacts, especially among older adults, during or after extreme weather events [22–26]. Community connectedness refers to the strength of social connections within or across communities. Participants emphasized the need for intentional community building following the COVID-19 pandemic, which disrupted many in-person social activities. Suggestions included intergenerational community events with food, as well as more formal heat preparedness planning, such as canvassing the neighborhood to assess household risk and developing a buddy system for neighbors to check on one another during extreme heat events. Authors Mason and Ekenga, in their study on neighbor checking during extreme summer heat and winter weather, found the practice to be a promising strategy to keep people safe during extreme weather events [25]. The literature suggests these interactions can serve as

wellness checks on at-risk community members and/or an opportunity for neighbors to validate information and share resources [20].

Participants identified several local service providers for their success implementing interventions among highly-impacted populations, including MoW and CARES, the Spokane Fire Department's (SFD) social response initiative. The CARES team receives referrals through SFD and connects individuals with needs beyond their physical health to social work students who conduct a social service needs assessment. Both MoW and CARES were highlighted for strong relationships between volunteers/providers and clients/patients. Participants viewed these social connections as invaluable during extreme heat events.

Additional funding is needed to support the expansion of existing heat risk reduction interventions (e.g. utility assistance) and for the development and implementation of new interventions (e.g. workplace training).

3.3. Collaboration

Participants noted that many heat risk reduction efforts are currently siloed and the region lacks a convener to bring organizations and agencies together. Despite this, participants highlighted several successful partnerships. Avista partners with local organizations, including MoW, to disseminate resources (e.g. fans) and to develop and pilot programs (e.g. senior rate discount). Spokane Public Library offers peer support services to individuals with behavioral health needs and those experiencing homelessness, through a partnership with Peer Spokane. While the program's focus is not on heat risk reduction, its effort to increase adaptive capacity among the population it serves, through onsite emotional support and referrals to community resources, was seen as increasing heat resilience among that population. Beyond these existing partnerships, participants expressed a desire for increased collaboration across sectors to streamline risk communication, increase resource sharing, and reduce the need to reinvent the wheel.

Participants urged collaboration across agencies and organizations to ensure unified messaging across diverse communication modes and to reduce noise fog. They suggested government agencies partner with community-based organizations and other trusted messengers to disseminate heat risk communications and noted that funding for these partnerships is necessary. Participants also discussed the possibility of public–private partnerships, such as with social media companies, to override algorithms and geo-target heat risk communications.

Participants expressed a desire for a centralized resource map where community members can access information about community resources, such as cooling center locations, services, and operating hours. Participants noted that funding and infrastructure for such a map would be essential to keep the information up to date. Finally, participants discussed the importance of establishing partnerships in advance of heat events.

3.4. Policy

Participants discussed historical policies that affect community members' disparate experience of, and ability to, respond to extreme heat events. They noted that housing instability is related to past and present policy and code enforcement and that a lack of affordable housing in Spokane increases the community's vulnerability to extreme heat. Systemic racism contributes to the overrepresentation of people of color living precariously housed and racist zoning policies and lending practices have created disparities in the built environment and contributed to urban heat islands [27, 28]. A 2022 heat assessment in the city of Spokane supports the symposium table discussions; findings from the assessment indicate a 13.9 °F temperature variation among neighborhoods during the day, with correlations found between urban heat, race, and income [29]. Participants also highlighted gentrification as a barrier to community connectedness and therefore heat resilience. One participant described the way displacement due to gentrification can disrupt social connection; 'families cannot afford to live in homes they have been in, so may feel uncomfortable even in [their] own neighborhood.'

Participants also discussed the lack of resources and support for people experiencing homelessness in Spokane, as well as harmful policies like sweeps. They described certain local policy decisions as 'fear-based' and noted that tactics used to deter unhoused individuals from using community spaces impact community-wide heat resilience. For example, participants discussed the lack of functioning water fountains at some public parks. One participant asked, 'why limit water supply to decrease drug activity?' While these conversations revealed a perceived association among participants with out of service public amenities and an effort by the city to deter public drug use, an article published by Spokane's Inlander newspaper reports that the wide-spread issue of inoperable water fountains in Spokane is a result of low city maintenance staff capacity [30].

In addition to historical and ongoing policy barriers to heat resilience, participants discussed barriers to policy change. Participants expressed a desire for local government to respond proactively rather than

reactively to extreme heat. They noted that climate change is a polarizing issue in their region and that the personal beliefs of elected officials impact local government's investment in heat preparedness and climate adaptation and mitigation. Participants discussed what they perceived as a lack of political will at the county level to devote necessary resources for heat preparedness; 'from the county perspective, the county is not interested in doing what the City of Spokane is doing as far as cooling centers. The only reason the city does it is a city ordinance. The county does not have that. It takes time, staff… This is political will.'

Despite these barriers, participants highlighted existing policy strengths and opportunities. SpoCanopy, a program of the City of Spokane and The Lands Council, seeks to increase the city's urban tree canopy, with a focus on planting trees in low-income neighborhoods that have low canopy coverage and disproportionate environmental disparities [31]. Participants praised this program and discussed additional methods to increase the city's urban tree canopy and reduce green space disparities such as by updating regulations related to tree requirements for new developments. They highlighted the splash pads program at city parks, city cooling centers, and Spokane Transit Authority's fare exemption program, which offers free rides to cooling centers in temperatures above 95 °F to individuals without fare.

Participants expressed a desire for a fully funded extreme heat task force to lead a proactive government response and coordinate across agencies. They discussed the need for heat action plans at the city and county levels. Participants highlighted the need for updated regulations and funding for code enforcement to protect workers (e.g. modified work hours), precariously housed populations (e.g. temperature control in landlord-owned buildings), and students (e.g. heat risk curricula and alternatives to outdoor activities). While Washington does not have a state-wide heat action plan, there have been policy changes at the state level as a result of the 2021 Heat Dome. Not long after the symposium event, the Washington State Department of Labor and Industries adopted Outdoor Heat Exposure rules in June 2023 [32], aimed at protecting outdoor workers. The following year, in July 2024, King County published an extreme heat mitigation strategy [33], which includes specific activities to protect precariously housed populations (e.g. renters, people experiencing homelessness) and people who work in and attend schools. Spokane can look to these examples as they move forward with heat action planning at the city and county level.

Participants discussed broader policy changes that would increase community heat resilience. Rent control was identified as a strategy to reduce housing instability among the population. Existing literature affirms that communities with large vulnerable populations are less likely to be resilient to disasters [34]. Increasing housing stability in the region would reduce the number of highly-impacted community members. Participants emphasized the need for participatory policymaking and more people with lived experience in positions of power. They also expressed a desire for their government to increase access to resources related to heat resilience, rather than take them away. For example, participants discussed the city's life jacket policy, which tickets boaters without life jackets. Participants envisioned their city providing life jackets to incentivize safe behavior, rather than fining those without the ability to afford a life jacket or fine. Participants discussed the increased risk of water-related injury during extreme heat events, a finding supported by state-wide emergency room data from the 2021 Heat Dome [35].

3.5. Research

Participants discussed practice-based research needs, including those related to housing, risk communication, and the impacts of climate change at the local level. They emphasized the importance of prioritizing participatory research methods. Participants highlighted the need to address housing stability in future research. They identified the need for a senior housing safety evaluation to understand the type and quality of housing available to older adults in the region. Participants questioned the accuracy of the Point-in-Time count of homeless individuals and discussed the possibility of conducting an additional count during the warmer months [36]. Additionally, participants acknowledged the need to better understand the specific vulnerabilities of precariously housed populations to extreme heat.

Participants discussed the need for a better understanding of how heat health risk communication is received across different populations and which messengers are seen as trusted. Additionally, they asked if and how the WetBulb Globe Temperature (WGBT) could be used by community members to better understand risk and make informed decisions. While the WGBT is a commonly used heat stress indicator among occupational agencies and the United States military, minimal research has been conducted on its use as a heat indicator in risk communications with the general public [37]. A study conducted in Taipei, Taiwan utilized the WBGT as the heat indicator for a pilot heat–health warning system. The findings from this pilot study suggest that the WBGT was the appropriate heat stress indicator for the pilot location's heat–health warning system, however further research is needed to account for local features of residents' heat exposure and threshold for heat.

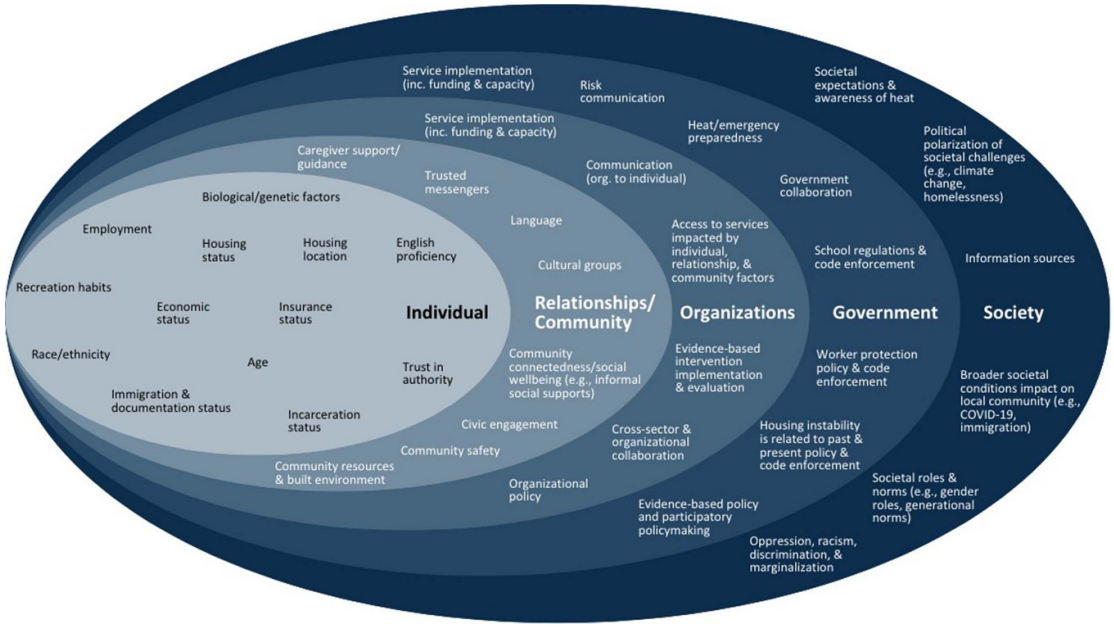

Figure 1. Heat resilience: a socio-ecological model. Adapted with permission from [38].

Participants called for research to extend beyond preparedness, into climate mitigation. They identified a need to better understand the financial impacts of climate change at the local level and explore solutions for making Spokane more livable (e.g. addressing heat islands).

3.6. Recommendations & Participant Prioritization

To illustrate the complex interplay of factors that govern an individual's experience of, and ability to respond to, an extreme heat event, we present our findings using the Socio-Ecological Model as a conceptual framework (figure 1). While the factors in this model are consistent with the SDOH, this model acknowledges that there are different levels of influence (i.e. individual, relationships/community, organizations, government, and society) and that community heat resilience requires risk reduction strategies appropriate at each level of influence.

Figure 1, adapted from the Mental Health and Well-being Socio-Ecological model by authors Michaels *et al* [38], illustrates the individual, relationships/community, organization, government, and societal factors that influence heat resilience. The Socio-Ecological Model depicts a complex system; the levels of influence are permeable as factors affect, and are affected by, factors at other levels. For example, community resources & the built environment appears under Relationships/Community because participants described parks and other resources (e.g. water fountains) as a part of how they experience their community. These community resources are made possible by public funding (Government), which is influenced by civic engagement (Relationships/Community). In table 3 we define the five levels of influence in our Socio-Ecological Model and provide example factors.

Symposium participants had the opportunity to prioritize heat risk reduction needs by highly- impacted population (work/recreation, precariously housed, underlying health conditions, and age-related) following the last round of table discussions. Common themes emerged across populations, which informed the recommendations below. Recommendations are organized by level of influence.

Individual—**Heat risk communications and heat risk reduction interventions should be tailored to the diverse needs of individual community members.** Participants highlighted the numerous factors that can influence community members' experience of, and ability to respond to, extreme heat events (e.g. age, housing status and location, and English proficiency). Direct service providers and policymakers should consider these factors when developing, implementing, and evaluating heat risk reduction strategies.

Relationships/Community—Community connectedness increases individual and community heat resilience. **Organizations and government agencies should work to facilitate and reduce disruptions to community connectedness.** Community connectedness can facilitate resource and information sharing, wellness checks, and prevent isolation and adverse mental health impacts before, during, and after extreme heat events. Organizations and government agencies can support community connectedness by hosting intergenerational events, providing funding for neighborhoods to host their own events (e.g. annual block

Table 3. Five levels of influence: definitions and example factors.

Individual	*Definition*	Factors that directly influence an individual's experience of, and ability to respond to, a heat event.
	Factors	Age, biological/genetic factors (e.g. underlying physical and mental health conditions), race/ethnicity, economic status, housing status & location
Relationships/ Community	*Definition*	Formal and informal social supports and community resources that influence individual and community heat resilience.
	Factors	Caregiver guidance/support, cultural groups, community resources & built environment (e.g. parks, sidewalks, etc.)
Organizations	*Definition*	Private and non-profit organizations, including services and relationships across organizations, that influence heat resilience.
	Factors	Service implementation (e.g. staff capacity), evidence-based interventions, cross-sector & organizational collaboration
Government	*Definition*	Laws, policies, and services that relate to heat resilience.
	Factors	Risk communication, worker protections, emergency preparedness & response
Society	*Definition*	Societal factors that influence heat resilience.
	Factors	Oppression & racism, cultural norms, political polarization of societal challenges (e.g. climate change)

parties), and implementing neighbor checking programs. These strategies are especially important following the COVID-19 pandemic and are needed to address the adverse impacts of the pandemic on community connectedness. Policymakers should also be aware of factors like gentrification that disrupt existing communities, and work to implement policies (e.g. rent control) to prevent further disruption.

Organizations & Government—Relationships are foundational to community heat resilience, from interpersonal relationships (see above) to collaborations across sectors. **Organizations and government agencies should leverage established relationships between community-based organizations and the communities they serve to develop and implement tailored heat risk communication and risk reduction interventions.** Such collaborations can reduce redundancy (e.g. risk communications) and strengthen the accessibility of information and interventions among highly-impacted populations. An extreme heat task force, with representation from highly-impacted communities, could help to establish and foster collaboration across the region.

Government & Society—**Upstream policy changes are needed to reduce inequality and the disproportionate burden of climate impacts on frontline communities.** Communities with large vulnerable populations are less likely to be resilient to disasters, including climate-related hazards like extreme heat. As policymakers seek to prepare their communities to adapt and respond to climate change, they must acknowledge and address the policies that have created and reinforced systemic disadvantage, making some communities more vulnerable than others. Policy changes to reduce economic and health disparities will contribute to overall community heat resilience. Examples include policies designed to reduce housing cost burden for low-income families and increase green infrastructure in formerly redlined neighborhoods.

All levels of influence—**Across all levels of influence, funding is needed to develop, implement, and evaluate evidence-based heat risk reduction strategies.** Participants described effective interventions (e.g. utility assistance) limited by current funding levels and emphasized the need for trusted messengers and people with lived experience to be paid for their work. Additionally, funding is needed for further research.

3.7. Limitations

The organizers of the symposium extended invitations to a diverse representation of local stakeholders, however not all invitees were able to attend the symposium or stay through the World Café discussion in the afternoon. It is likely not all perspectives and experiences were represented in the afternoon's conversations.

Additionally, the Socio-Ecological Model is limited in its scope. The model takes an anthropocentric view and fails to acknowledge the environment as an agent—one that influences and is influenced by human behavior. The development of a bi-directional model that is inclusive of the environment's role may allow for a more holistic approach to heat resilience in future research.

4. Conclusion

As climate change exacerbates hazards such as extreme heat, creating and sustaining heat-resilient communities has become an urgent global public health priority. Heat resilience requires risk reduction strategies appropriate at each level of influence, from policy solutions to strategies individuals and families can implement in their homes. Community engagement is essential to ensure these strategies are accessible to the communities and populations most highly impacted by extreme heat. The community engagement model described here is an example for other communities looking to build extreme heat resilience.

Data availability statement

The data cannot be made publicly available upon publication because they are not available in a format that is sufficiently accessible or reusable by other researchers. The data that support the findings of this study are available upon reasonable request from the authors.

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Ethical approval

This research was determined to be human subjects research that qualifies for exempt status by the University of Washington Human Subjects Division.

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Conflict of interest

None declared

ORCID iDs

A Reed https://orcid.org/0009-0001-5456-4042
B Henning https://orcid.org/0000-0002-3242-8138
T Busch Isaksen https://orcid.org/0000-0001-8180-6054

References

[1] Masson-Delmotte V, Zhai P, Pirani A, Connors S L, Péan C and Berger S 2021 *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* (Cambridge University Press)
[2] Davis R E, Hondula D M and Patel A P 2016 Temperature observation time and type influence estimates of heat-related mortality in seven U.S. cities *Environ. Health Perspect.* **124** 795–804
[3] Burkart K G, Brauer M, Aravkin A Y, Godwin W W, Hay S I and He J 2021 Estimating the cause- specific relative risks of non-optimal temperature on daily mortality: a two-part modelling approach applied to the global burden of disease study *Lancet* **398** 685–97
[4] Bell M L, O'Neill M S, Ranjit N, Borja-Aburto V H, Cifuentes L A and Gouveia N C 2008 Vulnerability to heat-related mortality in Latin America: a case-crossover study in São Paulo, Brazil, Santiago, Chile and Mexico City, Mexico *Int. J. Epidemiol.* **37** 796–804
[5] Kenny G P, Yardley J, Brown C, Sigal R J and Jay O 2010 Heat stress in older individuals and patients with common chronic diseases *CMAJ Can. Med. Assoc. J.* **182** 1053–60
[6] Arsad F S, Hod R, Ahmad N, Ismail R, Mohamed N, Baharom M, Osman Y, Radi M F M and Tangang F 2022 The impact of heatwaves on mortality and morbidity and the associated vulnerability factors: a systematic review *Int. J. Environ. Res. Public Health* **19** 16356
[7] Chersich M F, Pham M D, Areal A, Haghighi M M, Manyuchi A and Swift C P 2020 Associations between high temperatures in pregnancy and risk of preterm birth, low birth weight, and stillbirths: systematic review and meta-analysis *BMJ* **371** m3811
[8] Riley K, Wilhalme H, Delp L and Eisenman D P 2018 Mortality and morbidity during extreme heat events and prevalence of outdoor work: an analysis of community-level data from Los Angeles County, California *Int. J. Environ. Res. Public Health* **15** 580
[9] Spector J T, Bonauto D K, Sheppard L, Busch Isaksen T, Calkins M, Adams D, Lieblich M and Fenske R A 2016 A case- crossover study of heat exposure and injury risk in outdoor agricultural workers *PLoS One* **11** e0164498

[10] Iverson S A, Gettel A, Bezold C P, Goodin K, McKinney B, Sunenshine R and Berisha V 2020 Heat- associated mortality in a hot climate: maricopa County, Arizona, 2006–2016 *Public Health Rep.* **135** 631–9
[11] Arnold L, Scheuerell M D and Busch Isaksen T 2022 Mortality associated with extreme heat in washington state: the historical and projected public health burden *Atmosphere* **13** 1392
[12] Busch Isaksen T, Yost M G, Hom E K, Ren Y, Lyons H and Fenske R A 2015 Increased hospital admissions associated with extreme-heat exposure in King County, Washington, 1990–2010 *Rev. Environ. Health* **30** 51–64
[13] Casey J A, Parks R M, Bruckner T A, Gemmill A and Catalano R 2023 Excess injury mortality in washington state during the 2021 Heat Wave *Am. J. Public Health* **113** 657–60
[14] Understanding Extreme Heat Gonzaga University (available at: www.gonzaga.edu/climate-institute/our-work/climate-resilience-project/beat-the-heat/understanding-extreme-heat) (Accessed 6 December 2023)
[15] World Cafe Method 2015 The world cafe (available at: https://theworldcafe.com/key-concepts-resources/world-cafe-method/) (Accessed 22 Nov 2023)
[16] Hsieh H F and Shannon S E 2005 Three approaches to qualitative content analysis *Qual. Health Res.* **15** 1277–88
[17] Errett N A, Roop H A, Pendergrast C, Kramer C B, Doubleday A, Tran K A and Busch Isaksen T M 2019 Building a practice-based research agenda for wildfire smoke and health: a report of the 2018 washington wildfire smoke risk communication stakeholder synthesis symposium *Int. J. Environ. Res. Public Health* **16** 2398
[18] Madrigano J, Ito K, Johnson S, Kinney P L and Matte T 2015 A case-only study of vulnerability to heat wave–related mortality in New York City (2000–2011) *Environ. Health Perspect.* **123** 672–8
[19] NEJM Catalyst 2017 Social Determinants of Health (SDOH) *Catalyst Carryover* vol 3 (Accessed 26 Jul 2024)
[20] Burns R, Robinson P and Smith P 2010 From hypothetical scenario to tragic reality: a salutary lesson in risk communication and the Victorian 2009 bushfires *Aust. N.Z. J. Public Health* **34** 24–31
[21] Lundgren R E and McMakin A H 2018 *Risk Communication: A Handbook for Communicating Environmental, Safety, and Health Risks* 6th edn (Wiley)
[22] Aldrich D P and Meyer M A 2015 Social capital and community resilience *Am. Behav. Sci.* **59** 254–69
[23] Eady A, Dreyer B, Hey B, Riemer M and Wilson A 2020 Original mixed methods research—Reducing the risks of extreme heat for seniors: communicating risks and building resilience *Health Promot. Chronic Dis. Prev. Can.* **40** 215–24
[24] Kafeety A, Henderson S B, Lubik A, Kancir J, Kosatsky T and Schwandt M 2020 Social connection as a public health adaptation to extreme heat events *Can. J. Public Health Rev. Can. Santé Publ.* **111** 876–9
[25] Mason L R and Ekenga C C 2022 Keeping each other safe: who checks on their neighbors during weather extremes in summer and winter? *Disaster Med. Public Health Prep.* **16** 1537–44
[26] Pfefferbaum B, Van Horn R L and Pfefferbaum R L 2017 A conceptual framework to enhance community resilience using social capital *Clin. Soc. Work J.* **45** 102–10
[27] Harlan S L, Brazel A J, Prashad L, Stefanov W L and Larsen L 2006 Neighborhood microclimates and vulnerability to heat stress *Soc. Sci. Med.* **63** 2847–63
[28] Hoffman J S, Shandas V and Pendleton N 2020 The effects of historical housing policies on resident exposure to intra-urban heat: a study of 108 US urban areas *Climate* **8** 12
[29] Henning B, Ducken K, Honebein K, Farho C and Brown B Spokane beat the heat: correlations of urban heat with race and income in Spokane, Washington. Spokane beat heat correl urban heat race income spokane wash (available at: https://repository.gonzaga.edu/ccsereach/1) (Accessed 1 April 2023)
[30] Walters D (Inlander) Why do so many drinking fountains in Spokane parks not work? (available at: www.inlander.com/news/why-do-so-many-drinking-fountains-in-spokane-parks-not-work-22078786) (Accessed 26 July 2024)
[31] The Lands Council Urban Canopy (available at: https://landscouncil.org/urban-canopy) (Accessed 2 November 2023)
[32] Washington State Department of Labor & Industries Be Heat Smart (available at: www.lni.wa.gov/safety-health/safety-training-materials/workshops-events/beheatsmart) (Accessed 26 July 2024)
[33] Extreme Heat Mitigation Strategy King County, Washington (available at: www.kingcounty.gov/en/dept/executive/governance-leadership/climate-office/focus-areas/preparing-for-climate-change/extreme-heat-mitigation) (Accessed 26 July 2024)
[34] Committee on Post-Disaster Recovery of a Community's Public Health, Medical, and Social Services, Board on Health Sciences Policy, Institute of Medicine 2015 Healthy, resilient, and sustainable communities after disasters: strategies, opportunities, and planning for recovery (National Academies Press (US)) (available at: www.ncbi.nlm.nih.gov/books/NBK316532/) (Accessed 9 November 2023)
[35] Vogul J, Hess J, Kearl Z, Naismith K, Bumbaco K and Henning B G 2023 In the hot seat: saving lives from extreme heat in Washington State (University of Washington's Climate Impacts Group (available at: https://cig.uw.edu/wp-content/uploads/sites/2/2023/06/CIG-Report-Heat-202-pages.pdf)
[36] Point-in-Time Count and Housing Inventory Count HUD Exchange (available at: www.hudexchange.info/programs/hdx/pit-hic) (Accessed 26 July 2024)
[37] Lung S C C, Liou M L, Yeh J C J and Hwang J S 2023 A pilot heat-health warning system co-designed for a subtropical city *PLoS One* **18** e0294281
[38] Michaels C, Blake L, Lynn A, Greylord T and Benning S 2022 Mental health and well-being ecological model (University of Minnesota-Twin Cities) (available at: http://mch.umn.edu/resources/mhecomodel/)