What Makes a HeatReady School?

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ABSTRACT

BACKGROUND: The City of Phoenix initiated the HeatReady program in 2018 to prepare for extreme heat, as there was no official tool, framework, or mechanism at the city level to manage extreme heat. The current landscape of heat safety culture in schools, which are critical community hubs, has received less illumination. HeatReady Schools—a critical component of a HeatReady City—are *those that are increasingly able to identify, prepare for, mitigate, track, and respond to the negative impacts of schoolgrounds heat*. However, minimal attention has been given to formalize heat preparedness in schools to mitigate high temperatures and health concerns in schoolchildren, a heat-vulnerable population. This study set out to understand heat perceptions, (re)actions, and recommendations of key stakeholders and to identify critical themes around heat readiness.
METHODS: An exploratory sequential mixed-methods case study approach was used. These methods focused on acquiring new insight on heat perceptions at elementary schools through semi-structured interviews using thematic analysis and the Delphi panel. Participants included public health professionals and school community members at two elementary schools—one public charter, one public—in South Phoenix, Arizona, a region that has been burdened historically with inequitable distribution of heat resources due to environmental racism and injustices.
RESULTS: Findings demonstrated that 1) current heat safety resources are available but not fully utilized within the school sites, 2) expert opinions support that extreme heat readiness plans must account for site-specific needs, particularly education as a first step, and 3) students are negatively impacted by the effects of extreme heat, whether direct or indirect, both inside and outside the classroom.
CONCLUSIONS: From key informant interviews and a Delphi panel, a list of 30 final recommendations were developed as important actions to be taken to become "HeatReady." Future work will apply these recommendations in a HeatReady School Growth Tool that schools can tailor be to their individual needs to improve heat safety and protection measures at schools.

Keywords: extreme heat; elementary schools; heat preparedness; perceptions;

vulnerability

BACKGROUND

Overview and Literature Review

Schools are generally hubs for their surrounding community; they connect parents, teachers, children, faculty, residents, and families, meaning all are impacted by school heat conditions, preparedness, and policies. However, minimal attention has been given to formalize heat preparedness in schools to mitigate high temperatures and health concerns in schoolchildren. A 2019 Arizona state-wide school heat survey deployed by the Arizona Department of Health Services (ADHS) (Iverson et al., 2019) showed that informal school heat policies were more common than formal ones. The report found that while many schools have informal policies, actions subside due to inconsistent communication and organizational efforts in school districts, as well as a lack of funds.

Most heat-related research has come from the physical science domain (e.g., urban heat island studies, climate modelling) or from public health (e.g., estimates of mortality or morbidity at large spatial scales). In 2018, the City of Phoenix initiated the formulation of a HeatReady program to prepare for extreme heat, as there is currently no official tool, framework, or mechanism at the city level to manage extreme heat (Terrill & Faller, 2018). HeatReady Schools are critical components of a HeatReady City. The current study serves as a starting point to creating and operationalizing an evaluation rubric for schools, community partners, health departments, and researchers to use for heat preparedness at a smaller scale. Outcomes include the full participation of underutilized stakeholders, enhanced understanding of heat in schools, increased partnerships between academia and community, and strengthened literature around urban heat perceptions and school heat readiness.

The overlap in three domains of literature related to children's school health—safety, education, and environment—makes this research *unique* because it integrates public health, community perceptions, built environment, and learning into a cohesive community-based effort for school heat safety. Literature included justifies the need to operationalize heat mitigation and adaptation strategies in small-scale school community-level preparedness plans.

Heat safety (health and protection)

Heat-related illnesses can be fatal, as almost 1,200 deaths from exposure to excessive natural heat occurred in Arizona from 2006 to 2016 (AZDHS, 2020). In the last five years alone (2015-19), 83 children ages 5-9 and 198 children ages 10-14 visited the emergency department for heat stress in Maricopa County (Department of Health Services, 2021). Physical activity in the heat requires careful attention to the environment and adequate fluid intake, particularly to protect children from heat stroke. Heat illness can progress more rapidly when temperatures and humidity are high with minimal airflow (McGarr et al., 2021). Children are at a heightened vulnerability to heat for various reasons. Their sweating mechanism is still underdeveloped (thus, less cooling via evaporation occurs), as is their experience with heat, making it difficult to understand changes in their physical condition (Hatori, 2013). Because their sweating and acclimatization rates are slower than adults, they produce more metabolic heat per kilogram of body weight, and the temperature at which sweating begins is higher (Bytomski et al., 2003). Thermal environments also affect psychological responses and cardiovascular functions, increasing the risk of illness or mortality in children (Papanastasiou et al., 2020). Given these concerns, community preparedness is essential, such as pre-planned and coordinated rapid response capability, an expert and

fully staffed workforce, and accountability and quality improvement, with a focus on communication and education regarding heat (Wodika, 2013).

Further, school heat response in Arizona is often based on informal protocols (Iverson et al., 2019), and actions subside as staff communication is inconsistent. Focusing smaller-scale heat action plans—ones that are correlated to city and county-wide plans—will help boost adaptation and mitigation strategies, intra-urban connectivity within Phoenix, and address communication gaps in plans, ultimately making schools and the city more resilient to heat.

The impacts of heat on learning

A study by Olinger et al. (2017) defined natural disasters as hurricanes, earthquakes, or tornados, which are present in school crisis plans; however, these plans were found to exclude heat from any type of hazard, further demonstrating that heat is not directly perceived as a health priority in schools. High temperatures affect student behavior and may cause students to be listless, fatigued, and restless, impacting their educational environment and potentially compromising learning (Hyndman, 2020). Porras-Salazer et al. (2018) conducted a study on the impact of thermal comfort on educational performance in a Costa Rica school. Results indicated that elevated temperatures should be avoided because academic performance and learning are negatively affected by the heat; to create an optimal teaching environment, the design of a school must account for the thermal environment in classrooms (Porras-Salazar et al., 2018).

Communication and policy plans around a range of heat are vital because "school staff must understand the mechanisms of escalating risk and be supported to undertake action to reduce the level of risk through appropriate policies, procedures, resources and action plans" (Hyndman, 2017, p. 68). A case study by Hyndman (2017) focusing on

policies around extreme heat concluded that school heat policies should include *five key action areas*: (1) healthy school policy (flexible scheduling of activities, uniform [clothing] adaption); (2) heat supportive environments (shade provisions, hydration strategies, development of heat-protective guidelines and charts); (3) heat-protective community action (development of communicative methods to parents such as social media, provision of preparatory information to parents, feedback from the community on strategies); (4) heat protective community skills (skill development on accessing heat protective resources; monitoring hydration skills; nutritional considerations); and (5) focus on the prevention of heat illness (monitoring of staff & students; aligning with curricular content. The five action areas provide broad and essential areas of focus for all schools to ensure child well-being.

Environment (playground and school environment)

Playgrounds and schoolyards have minimal shade and high surface temperatures when sun-exposed (Vanos et al., 2016), which can cause miniature heat islands within the already hot urban environment (Moogk-Soulis, 2010). Overexposure to heat and sun present near-term issues, such as heat stress, heat illness (e.g., vomiting), and skin burn (Vanos, 2015), as well as long-term chronic health problems, such as adult skin cancer.

A study by Vanos et al. (2016) in Phoenix, AZ examined surface temperature magnitudes in playgrounds and the impacts of design and shade on these temperatures. Their study showed that materials with high heat capacities and/or thermal conductivities (e.g., black rubber, concrete, asphalt, artificial turf, steel, aluminum) transfer heat quickly to the skin, and thus have a higher potential to cause extensive burns to children (Vanos et al., 2016). Kennedy et al. (2020) outline that thermally comfortable playground spaces and equipment are important during all seasons of play so that children can go outdoors, play, and learn actively for longer periods. Playground

safety standards have helped prevent injuries and improve the safety of playground equipment and materials, yet many important environmental factors are neglected in these traditional playground safety standards, including high temperatures (Kennedy et al., 2020). Results from a U.S.-based study by Olsen et al. (2019) results strongly motivate the assessment of playground heat exposures and the provision of thermal comfort principles, as well as trees and greenspace, play a more centralized role in playground design. In summary, thermal safety and comfort are paramount in optimizing children's emotional, physical, and social play experiences (Kennedy et al., 2020).

Overall, it is well-known that *heat is dangerous to school children with varying impacts to behavior, learning, and physical health; however, little is known surrounding knowledge, perceptions, and actions in schools to reduce heat-health risks to school children. Knowledge gaps above highlight* that 1) small-scale heat preparedness plans warrant communication and education enhancements, 2) perceptions of (and plans for) extreme heat in schools are diverse and site-specific, 3) at-risk populations (children) are exposed to high levels of heat in a playground environment

Purpose and Research Questions

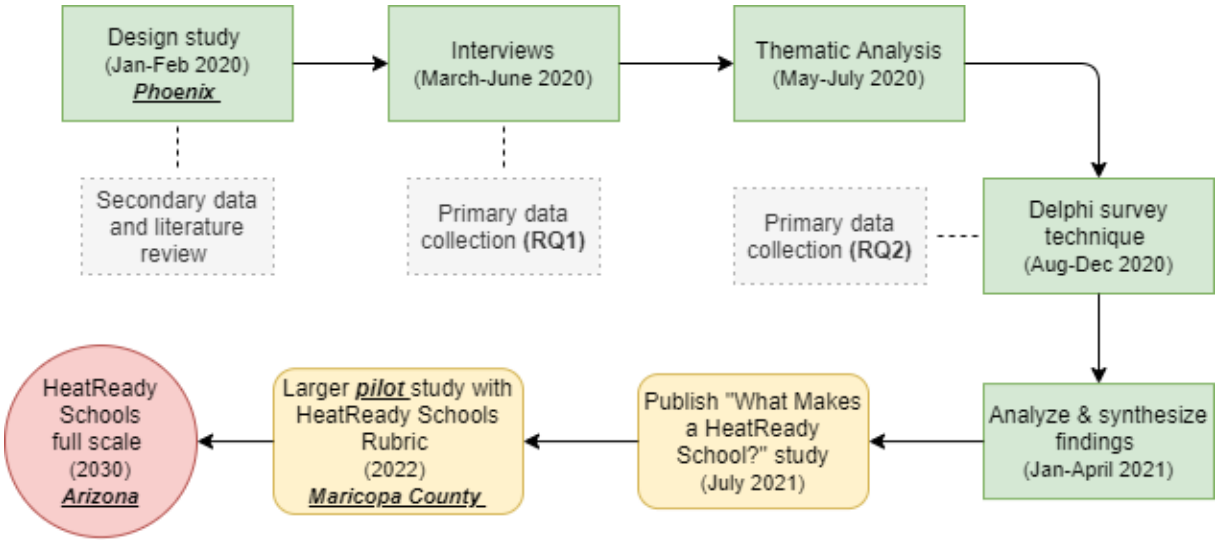
This study seeks to understand the current state of heat preparedness plans at schools for student well-being. **Research objectives** include: 1) to improve our understanding concerning heat perceptions, (re)actions, and recommendations of key stakeholders, and 2) to identify themes from expert stakeholder responses to gauge the effectiveness of their heat preparedness levels in their current environment. **Research questions** are:

1) How is heat perceived by key stakeholders at K-8 elementary schools?

2) What are the defining characteristics of a HeatReady School?

The **overarching goal** is to improve the safety and protection measures of children exposed to extreme heat during the school day by creating a HeatReady Schools Rubric. The temporal sequence of this study's design, synthesis, and future plans are shown in Figure 1.

Figure 1. Timeline of the HeatReady Schools project from its conception point to future research plans. Boxes in grey identify data collection points, green indicates actions already taken, yellow indicates future research plans to scale-up the research, and red indicates the final overarching goal of this process; to create HeatReady Schools.



METHODS

This case study uses an exploratory sequential mixed-methods design (Fetters et al., 2013; Schoonenboom and Joneson, 2017). The case study focus—two South Phoenix elementary schools—involves intensive qualitative and quantitative data collection (Fetters et al., 2013; Schoonenboom and Joneson, 2017). Participants were chosen based on level of knowledge, experience, expertise, and/or association to heat in schools. Data collection through semi-structured interviews followed by three rounds of Delphi surveys allowed space for participants and data to speak openly. Interviews were analyzed using thematic analysis, and Delphi survey results were analyzed using the SORT taxonomy. See Table 1 for the study design outline.

Table 1: Summary of design protocol for each research objective and question, including participants, data collection methods, and analysis approaches.

Process	Sample Size	Source	Data Collection	Analysis Approach
RQ/RO #1	9	Teachers, Coach, Parent, etc.	Semi-Structured Interviews	Thematic Analysis
RQ/RO #2	21-28	Panelists (e.g., epidemiologist, principal, parents)	3 Rounds Delphi Survey	Delphi Technique

Study context

Participants included school community members at two elementary schools—one public charter, one public—in South Phoenix, Arizona, as well as public health professionals. This region has been burdened historically with environmental racism and injustices, increasing the risk and environmental hazards, such as air pollution, across this industrialized zone (Bolin et al., 2000) (see Table 1). The school sites in this study add a layer of urgency to rationalize studying in South Phoenix, an area that lacks heat coping and mitigation resources and has historically faced environmental racism and injustices (Bolin et al., 2005).

Instruments: Interviews and Delphi Panel

This mixed-methods study used an inductive approach to gain a deeper understanding of the perceptions of heat from key informants that are vital to children's health during times of high heat. First, semi-structured interviews were performed to gain insight from the experts/participants through open sharing about their background, stories, thoughts, experiences, and recommendations surrounding extreme heat and impacts on schools. This method used in-depth discussions, as opposed to statistical representativeness, to better understand heat readiness in Arizona public elementary schools (Bernard et al., 2016). Such methods also allowed more rich data to be used as support for the development of the Delphi survey, of which ensured a breadth of

perspectives were accounted for. The inclusion criterion for these key informants limited the number of qualified interview participants (outlined below). A small interview sample size (n=9) was chosen because complete saturation is not the appropriate criterion for the goal of this component, which was to inform the Delphi survey questions.

Second, a modified Delphi panel method with a larger key informant base (22 panelists on average per round) was used to generate recommendations and guidelines. The Delphi method allows panelists to maintain anonymity, thus encouraging more open and honest feedback (Bhattacharya, 2017; Ziglio and Adler, 1996). Although focus groups were considered, the Delphi technique was more feasible considering COVID restrictions and offered a more inclusive, convenient, and anonymous participatory research process with the community stakeholders.

Participants: Interviews and Delphi Panel

This key informant sampling was used for primary data collection for reflection and descriptive feedback from several perspectives. Interviewees and Delphi panelists ranged from school staff to public health officials. Specifically, interview participants included a nurse, librarian, teachers, sports coach, epidemiologist, parent, and community health official. Delphi included participants people across different areas of expertise—health, policy, academic, parental, and administrative.

Key informants in this case study were chosen based on first-hand personal experience in heat exposure (Marshall, 1996). As such, these participants were selected based on their level of knowledge, experience, expertise, and/or association to heat in schools using one or more of the following criteria:

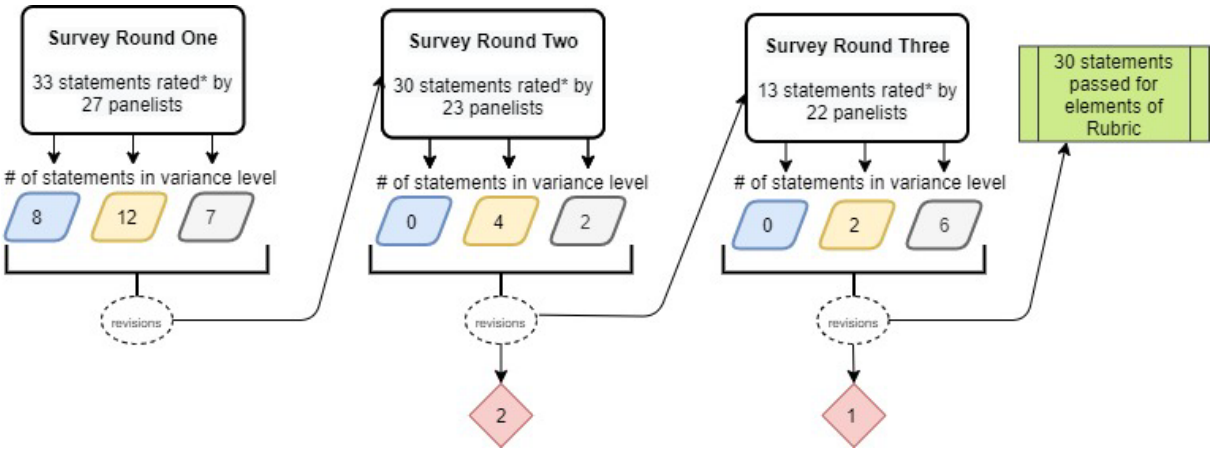
- Job title implies they have knowledge or experience with children in South Phoenix schools and/or experience understanding extreme heat in schools.

- Roles/responsibilities may influence heat readiness in some way at elementary schools.
- They are willing to communicate knowledge to an interviewer.

Procedure: Study Design and Protocol

Due to COVID-19 restrictions, the nine semi-structured interviews were completed on the Zoom platform or via phone call. Each interview was recorded, lasted one hour, and notes were taken on the interviewer's laptop for reference during data analysis. All interviews were transcribed. Interview questions were constructed using five major themes gathered from the framework for "Heat-Smart" schools based on the five action areas developed by Hyndman (2017) (i.e., training, prevention, school policy, community, environment). The final interview contained 16 questions and allowed flexibility for the interviewee to expand on stories/experiences, ideas, suggestions, and opinions.

*Figure 2: The Delphi panel survey technique process below describes the iterative nature of the quantitative component. This figure shows 1) the Delphi process, 2) the progression of variance in panelist responses, and 3) disposal points of statements. Blue= variance level 7-9, yellow = variance level 6-4, grey = variance level 3-1 = grey, red = number of statements discarded. *rated using a 10-point scale (0-9). NOTE: each round of surveys included one tester question for panelists.*



The process of the Delphi panel, outlined in Figure 2, allows each expert to provide anonymous responses and comments, thus allowing them to fully express opinions freely, encouraging open communication (Bhattacharya, 2017). Participants

were given three weeks to complete each round of surveys via Qualtrics; facilitators had one week for revisions and turnaround. Each participant was given a 'panelist packet'—a report created for guidance and support—containing project context, goals, and individual responsibilities and expectations. Survey statements were generated from themes and key points that emerged from interviews and Hyndman's 'Heat-Smart' school five action areas.

The Delphi cycle of clarification, expansion, and identifying areas of agreement or disagreement continued until the majority agreed. To help alleviate panel shrinkage, 36 people were initially asked to participate in the Delphi panel; 27 panelists responded in round one. Each panelist received an electronic survey (Qualtrics) with three weeks to complete, followed by one week of revisions by the facilitators.

Each statement was accompanied by a 10-point (0–9) scale ranking three components: 1) *validity*—operationally defined as whether the recommendation is substantiated based on current data, theory, literature, or another type of scientific evidence, 2) *feasibility*—operationally defined as whether the recommendation is realistic to expect individuals or campuses to implement, keeping in mind the widely varying resources and competing demands that individuals and institutions may face, and 3) *clarity*—operationally defined as whether the recommendation is clear and easily understood (Ziglio and Adler, 1996). Higher scores (7–9) along the 10-point scale depicted a recommendation being more valid/feasible/clear, lower scores (1—3) depicted an area of disagreement. For any score ranked 4–6, panelists were asked to provide further description in an open-ended comment box. Additionally, open-ended questions were added at the end of rounds 1 and 2, as seen fit by the facilitator(s), to go deeper into understanding current school community heat-health knowledge. These open-ended questions inquired into the location of information where panelists receive

their information for “hot days”; if they are aware of and/or interested in ADHS current heat resources; and their opinions on the formatting of the HeatReady Schools Rubric. Round one of the Delphi survey helped gain a broad range of opinions from the group of experts, which provided the basis for round two statements. The second round filtered out highly variable statements, which prepared and clarified the most conflicting/inconsistent statements in round three to seek consensus.

Data Analysis

Interview data were transcribed and coded using Zoom and MAXQDA, respectively. Descriptive thematic analysis of the interview data followed the steps: familiarization with the data, generate first initial codes, search for themes, review potential themes, define and name themes, create a report (see Figure 3) (Braun and Clarke, 2012). Interview themes were used in combination with participant feedback, current Arizona heat policy initiatives and resources (e.g., Heat Safety School Toolkit, ADHS framework for policy, and Hyndman’s framework for ‘Heat-Smart’ schools (Hyndman, 2017)).

The Delphi method further ensured that multiple perspectives were heard in creating the evaluation toolbox for greater inclusivity and efficiency. The survey analysis process was divided into three rounds (see Figure 2). Statements were ranked based on their mean values ≥7, number of comments, and level of variance, which indicate the level of agreeance among panelists. Statements’ were considered ‘agreed’ upon by panelists based on mean ≥7 and low variance (disagreement) levels in validity, feasibility, and clarity. Comments and ranking were also evaluated using the Strength of Recommendation Taxonomy (SORT); A—high-quality, quantity, and consistency of evidence, B—limited-quality, inconsistent or low quality, quantity, or consistency of

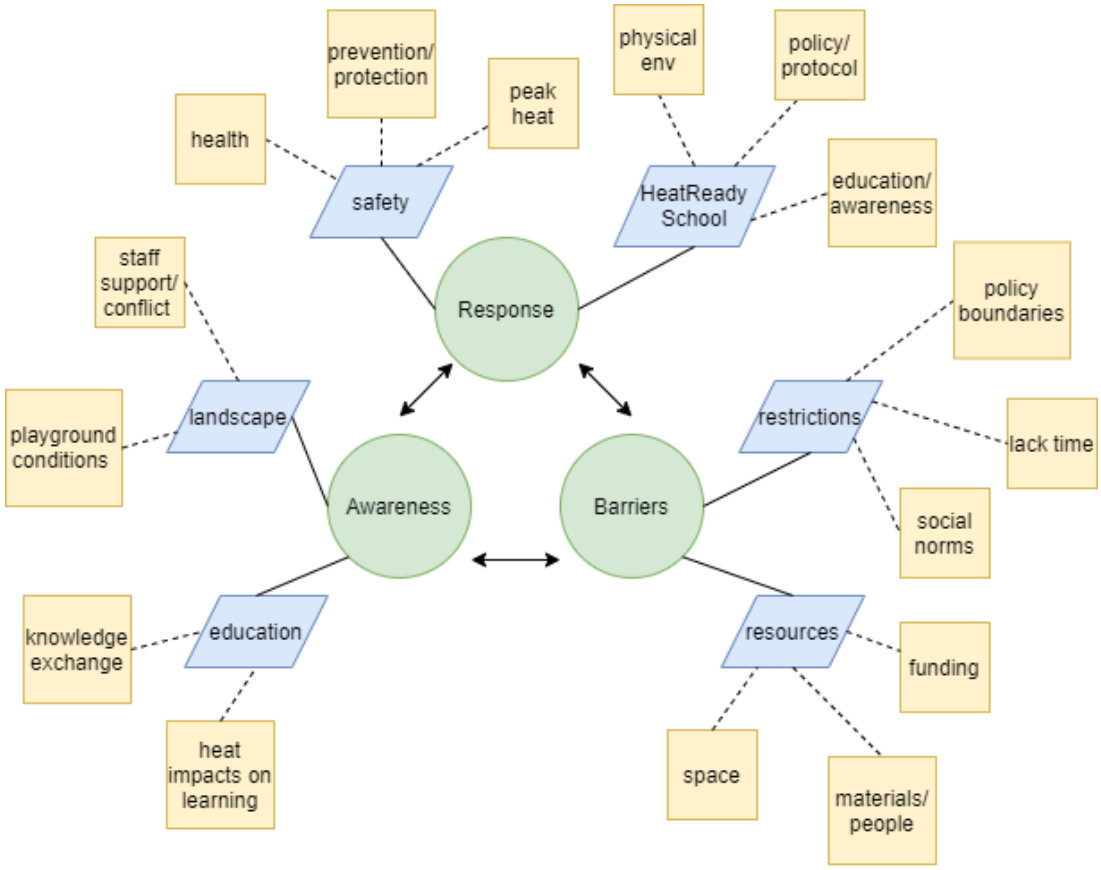
evidence, C—general consensus, usual practice, opinion (Ebell et al., 2004; Scheer et al., 2021; Chang et al., 2020).

RESULTS

Interviews

Interview and Delphi survey questions were created and thus sorted into categories in the results, from Hyndman's five action areas—*school policy, environment, training, prevention, and community*—and the ADHS resources on extreme heat in schools. The general themes (Figure 3) that emerged from interviews were 1) awareness, 2) response, and 3) barriers.

Figure 3: Concept map of themes (green), sub-themes (blue), and codes (yellow) from the interview results; solid lines connect themes to sub-themes, dotted lines connect sub-themes to codes, arrows represent the relationship between connections of participant responses. Themes—response (to extreme heat), awareness (of heat dangers), barriers (to prevention and protection)—represent patterns and meanings within responses and categories. Analysis process began with familiarization of transcripts, generating initial codes, searching for themes, quality check themes, define and name, and then produce a report (Braun and Clarke, 2012).



Interview participants had many stories to share about their experiences with extreme heat, such as its impact on their lives, the impact on students, and the impact on their family and/or community. They further shared their coping strategies and knowledge/awareness, their opinions and recommendations about future management, and information on how elementary schools in South Phoenix are responding to heat. Themes emerge through sub-themes that develop from individual codes; interview responses explained:

- The level of *awareness* (of heat issues for children) in interview participants is high and emerged through heat education and landscape (physical and social environment) sub-themes. Stories from participants expanded upon how they have witnessed high heat impact students' learning inside/outside the classroom and how knowledge is exchanged between staff and students about protecting/responding to extreme heat, what/how playground conditions influence heat safety culture at their school, and instances of interpersonal communication about heat being supported or inciting conflict.
- *Response* levels were examined through questions about heat safety (timing, response, and impacts) and opinions of what comprises a positive culture of Heat Readiness at schools (education, training, and environments). Responses indicated that heat safety is perceived as very important; stories about peak summer heat, physical and mental health impacts on students and staff, and measures taken for heat illness protection demonstrate that interviewees take action within their capacity level Opinions of what makes a Heat Readiness culture revolved around improving education, policy, and physical environments.

- *Barriers* to establishing or improving heat safety cultures in schools manifested through restrictions (time, policy, culture) and limited resources (space, supplies, funding). Boundaries from policies (or lack thereof), their severe lack of time, and/or the past/present culture of heat awareness in their school often prevent staff from taking more direct action. Responses about furthering action for high heat protection indicate that schools are hindered by underfunding, limited indoor spaces, and insufficient supplies/people.

Public health and academic interviewees overall agreed that extreme heat in elementary schools is an increasing problem, and low-income populations are of greatest concern. Microclimatic differences within elementary schools were important for understanding the variety of needs and priorities among interviewees. One expert panelist pointed out that "every school has a specific condition, abilities, resources. So, what works for one school will not work for another school. The microclimate of one school is not the microclimate of the different schools."

In this case study, the charter public school had an informal and relatively consistent strategy for preventing and responding to heat illness in their setting. Overall, their staff is *aware* of heat as a hazard in their school and *respond* using reasonable safety precautions to protect and educate students and staff within their current means (i.e. nurse and principal check weather daily during heat season, Principal's decision to keep kids inside if over ~105°F (40.5°C), heat illness posters are present in nurse's office, teachers give cool downtime in classrooms after recess, etc.). One participant noted that they "have signs up all over and encourage [the students] to make sure that they're drinking plenty of water" and another said the "principal and the nurse…support us every day, they give us instructions to be careful with the heat." These actions are helpful, but this school's participants stated that "we don't have a lot of that in place

right now because we don't have the funds" for more outdoor shade, building educational policies, and alternative indoor activity spaces. *Barriers* like these (i.e., space and cooling amenities) indicate that more action is needed to improve their heat preparedness.

The public school, on the other hand, struggled with administrative staff turnover rates and an inconsistent heat safety culture, including communication and responses about heat. Recent replacements in the Principal's role altered how staff perceive (*awareness*) and *respond* to heat at this elementary school. According to the interviewees, recess or sports activities had never been adjusted/moved indoors/canceled due to high heat under the previous Principal's reign. However, since staff turnover, outdoor activities have since been adjusted in some way to protect staff and students from extreme heat, which was reported to be a "huge shift for the teachers on [their] campus." Heat safety culture within this school demonstrated how important behavior change and education is—"even though the teachers do talk to [the students] about it," yet it was shared that some children will still wear their hoodies on 110°F+ days. Teachers in this setting have "scheduled [recess] duty at certain times. Some teachers choose not to do that… [when] nobody's there, supervising the kids, that's where we have problems." One interviewee shared that at times "kids are going to play outside for 30 minutes, even though it's 112 degrees outside… [our school] very much values their teachers' lunchtime". *Barriers* manifest in this school setting via teachers not wanting to feel like they have another responsibility, principals do not want to have to sacrifice already-limited funds, and policymakers encouraging education but lacking sufficient resources/capacity to execute heat readiness as desired or needed.

Delphi Survey Panel

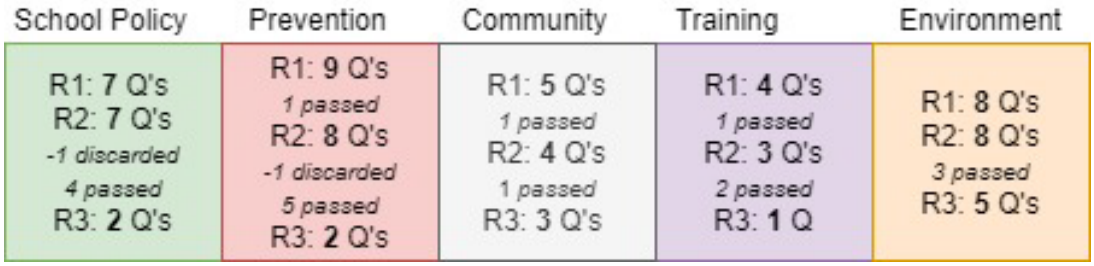
Despite pandemic restrictions, particularly for schools, panelists were engaged and interested in dedicating their energy towards improving heat readiness in schools through the online Delphi surveys. Given that the Delphi survey lasted 4 months—beginning in the September heat—panelist participation from start to finish was highly successful, with an attrition rate of only 20.4% (see Table 2). Round one (R1)—27 panelists—began at the end of September 2020; round two (R2)—23 panelists—ended November 2020; and round three (R3)—22 panelists—wrapped up mid-December 2020.

Table 2: The progression of panelists' responses and number of questions in relation to Hyndman's action areas/categories from survey round one to three Range of respondents = minimum and maximum number of panelists who ranked statements in this area..

	Round ONE		**Round TWO**		**Round THREE**	
Category/ action area	*# of Q's*	*Range of respondents*	*# of Q's*	*Range of respondents*	*# of Q's*	*Range of respondents*
Policy	7	19-23	7	20-22	2	19
Environment	8	20-24	8	21-22	5	19
Training	4	21-22	3	19-21	1	17-18
Prevention	9	21-24	8	21-22	2	19
Community	5	21-23	4	20-21	3	18-19

The final results from the Delphi survey consisted of 30 recommendations based on expert panelist consensus. Responses varied the most in the *community* and *training* categories, where the school setting and solutions pathways to improving/establishing relationships and educational training are broad yet require specificity (see Figure 4). Although most panelists agree that it would be beneficial to allow the community after-hours access to schoolyards as outdoor cooling centers (to offer refuge from the heat), concerns for child safety and budgeting for such space use were a higher priority. Further, most panelists agree on requiring or encouraging heat safety training before the heat season; however, suggestions about the training source (i.e., AZDHS webinar, CDC trainings, NWS services) differed.

Figure 4: Visual demonstration of categories—derived from Hyndman's five action areas—that panelists responded to with the least or most disagreement, where "passed" represents a statement being fully accepted, and "discarded" resulted in a statement being removed. The most disagreement (and thus variance) occurred in statements about community and environment, and thus R3 saw higher statements in these categories and varying feedback. The variance points out that community and environmental action areas are where elementary schools in South Phoenix face particularly challenging barriers to overcome. School policy, prevention, and training action areas reached agreement among panelists through a higher percentage of passed statements in the given category earlier in the process.



The majority of panelists agreed on improving *environment*al infrastructure outdoors, yet a wider variance was present as to how schools reach that goal, mainly due to funding or other district limitations. For example, panelists agreed that schools should have more shade for heat and sun relief, but opinions differed based on defining the extent and location of shade coverage, funding, designing, and implementing 'heat relief zones.' Additionally, one of the greatest concerns panelists expressed was how the variety between and within school settings (*environment*) could heavily influence how, where, and what strategies to implement for improving heat readiness.

Responses in the *school policy* category demonstrated that staff and health professionals struggle most with resource and capacity barriers—being understaffed/funded and overworked/committed. Opinions also varied about the extent of formality of heat policies/protocols and what level of action should be encouraged or required at schools.

Panelists' responses about *prevention* strategies (category with the most statements) agreed that plans could be enhanced for better protection of the students from extreme heat, but the process of those plans—assigning people responsibilities, establishing a cohesive plan, determining effective communication strategies—was

most explored. Establishing outside partnerships for supplies/resources was a heavily examined statement in the *preventative* category. Final results include 30 recommendations (Table 3) that 'passed' Delphi panelist feedback to create a HeatReady Schools Rubric and three statements were discarded because of high variance and high disagreement in comments.

Table 3: 30 recommendations that 'passed' the Delphi expert panel, thus representing agreement on the appropriate components and/or actions part of for a HeatReady School. . Each recommendation has been assigned a Strength of Recommendation Taxonomy based on Hosowaka et al., (2021) and Ebell et al., (2004).
A = Recommendation based on consistent and good-quality evidence – high quality, quantity, and consistency of evidence.
B = Recommendation based on inconsistent or limited-quality evidence – inconsistent or low quality, quantity, and consistency of evidence.
C = Recommendation based on general consensus, usual practice, opinion, etc.
To have strong evidence in this table, research studies or consistency of evidence is based largely on studies with children, on schools, or in playgrounds.

Action Area	Recommendation
School Policy	**[C]** A HeatReady school has formal guidelines for heat-related actions taken within the school.
	[C] A HeatReady school has a protocol for communicating effectively with parents about heat via multiple communication channels (emails, texts).
	[A] A HeatReady school has an emergency heat response plan document that includes location(s) of medical resources, a plan in case heat illness is experienced (staff and students), and how to respond appropriately.
	[C] A HeatReady school has a formal protocol for changing the schedule of school activities and programs during high heat periods.
	[A] A HeatReady school has access to a health professional, such as a nurse or aide.
	[A] In a HeatReady school, teachers and staff pay attention to signs of heat distress in students. [1]
	[C] A HeatReady school has a pre-existing staff member whose responsibility includes heat readiness actions, advocating for heat mitigation/adaptation, and networking with other schools.
Environment	**[B]** If space is available, HeatReady schools near busy roads have vegetative barriers (bushes, trees, dense planting) to reduce heat exposure.
	[C] In a HeatReady school, students have access to a reusable water bottle for staying hydrated.
	[A] In a HeatReady school, the playground area (e.g,. where students have recess) has more than 50% of shade coverage (from trees, built structures, buildings) during the hottest points of the day.
	[C] A HeatReady school has one or more heat relief zone(s) (e.g., an area where one may seek cooling refuge from direct sun) near a water fountain that provides clean and cold water.[2]
	[A] A HeatReady school encourages having shaded outdoor cooling zone(s) that effectively uses a mix of shade types (shade sails, building shade, trees) on campus.

	[B] A HeatReady school encourages students and parents to send the kids to school with effective personal heat protection gear (e.g. sunscreen, wide-brimmed hat, sunglasses, cooling towel).
	[C] A HeatReady school has an appropriate space for alternative indoor recess activities during dangerous heat days.
Training	**[C]** A HeatReady school requires all active members at the school in (e.g. administration, students, and parents) to take an annual heat training on how to identify and respond to heat illness and exhaustion each spring to prepare for the heat season.
	[C] A HeatReady school collaborates with the public health department and/or heat experts for educational materials and trainings before making heat readiness plans.
Prevention	**[C]** A HeatReady school communicates with their district/school board about heat protection and mitigation (education, infrastructure, planning) within budget boundaries.
	[B] A HeatReady school educates parents, teachers, students, and staff about individual heat protection behaviors, such as wearing clothing that's effective for cooling.
	[A] A HeatReady school encourages hydration before/during/after all recess hours and outdoor activities, especially during high heat periods.
	[C] A HeatReady school requires heat illness education posters to be hung on major entrances, exits, playground area, and nurse's office throughout the school.
	[C] A HeatReady school trains existing recess monitoring staff on heat illness protection, prevention, and response.
	[B] A HeatReady school has passive or low energy methods to respond to periods of high heat (e.g. fans, window blinds, cooling rags, shade, water). [3]
	[C] A HeatReady school addresses heat preparedness plans in school board and PTA meetings before and during warm season.
	[B] A HeatReady school adapts the time and intensity of gym classes and sports practice when it's dangerously hot. [4]
	[C] A HeatReady school uses outside partnerships and donations for providing cooling supplies (ice packs, ice vests, water bottles, electric fans, cool towels, etc.) to their nurse(s) to help students in need.
	[C] A HeatReady school includes indoor/outdoor monitoring heat illness instances (e.g. classroom teachers, recess coaches, sports coaches, librarians, etc.) in their current health tracking system(s).
Community	**[C]** HeatReady schools include the child's susceptibility to heat illness as a factor in the student's health information provided by their parents, of which the school encourages parents to offer.[5]
	[C] A HeatReady school ensures that students/staff have access to heat relief area(s)/protective gear (e.g. trees, shade sails, or personal umbrellas) during long wait times in the walking and car/bus loading areas.
	[C] A HeatReady school is connected to a network of other schools that shares best practices and guidance on heat readiness.
	[C] A HeatReady school is involved in community cooling mitigation and adaptation, amplifying the voices of parents and residents.

[1]The responsibility of "who" pays attention to was more scrutinized than the well-known subject of heat distress in children.

[2] Heat refuge and cooling relief zones have been more researched than evaluating the effectiveness of placement near cold and clean water fountains.

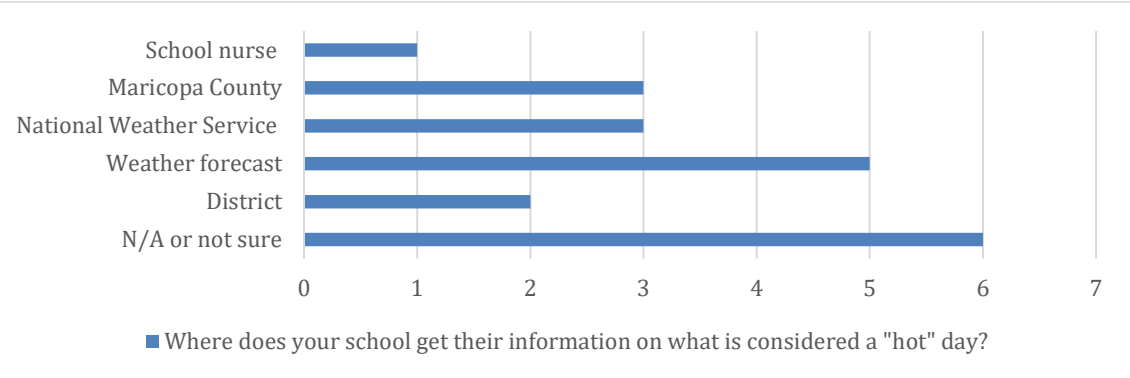
[3] Passive cooling methods have been more studied than their utilization and effectiveness in schools.

[4] Supporting evidence in the sports world, but more studies are needed to test effectiveness in elementary schools.

[5] Emphasis on the individual students' health, and quality of evidence on that.

Round two included three additional open-ended questions aimed to understand the level of knowledge about (education/awareness) resources currently available for schools to help prepare for extreme heat. Figure 5 shows the response to understand where schools find their information on "hot days", showing a generally even spread among sources.

Figure 5: Open-ended question asked in survey round one (n=22). Question: "where does your school get their information on what is considered a "hot" day?"



The remaining open-ended questions found that 50% of the 22 respondents were not aware of the ADHS "Heat Safety – School Toolkit" resource, and 61% did not know that you can sign up for "School Heat Alerts," yet 63% of respondents were interested in signing up, while 27% said maybe.

DISCUSSION

The current study used a mixed-method approach to understand perceptions and consensus around creating HeatReady Schools in South Phoenix. Interview results demonstrate that Phoenix schools and residents are aware of extreme heat dangers and impacts, but financial and resource barriers usually prevent more formal or abundant preventative actions from being taken. Delphi panel results helped identify key stakeholders' opinions and suggestions about what characteristics make up a HeatReady

School. The 30 final recommendations will 1) contribute to the ADHS efforts in creating a school heat policy, 2) support more small-scale operations to make a HeatReady City, and 3) lay the foundation for long-term climate planning in elementary schools (ADHS, 2021; Terrill and Faller, 2018; Olinger et al., 2017). Additionally, survey findings will contribute to Delphi panel literature, specifically using a modified, mixed-methods approach to the goal and platform (Hosokawa et al., 2021). In conjunction with the ADHS school heat policy, this project will help support the momentum needed to prepare more schools in the Southwestern region for the impacts of extreme heat (ADHS, 2021).

Responses from participants underlined that school staff witness and experience negative impacts of extreme heat in students (and themselves). Open-ended questions in the Delphi survey demonstrated that a large portion of key stakeholders is unaware of the health and safety resources available to them now; ADHS Heat Safety – School Toolkit, school heat alerts, and free educational trainings. The ADHS resources—school toolkit and extreme heat recommendations guidance document—are a starting point (as some information may become outdated) for boosting heat readiness within schools. But the communication gap of knowledge and resources warrants further research to understand the barriers, needs, and wants of each school. Understanding these will help improve vulnerability assessments, monitoring, and evaluation of heat preparedness at a community scale—such as nurses tracking heat-related illnesses in their school. This disconnect between not knowing what is currently available to schools further warrants improvements in *preventative* measures taken on-site, as outlined by Hyndman (2017), and the need for a school heat policy, which is in process for Arizona (ADHS, 2021). School communities should visit the Extreme Weather and Public Health page for schools on the ADHS website. Here you can find 1) a Heat Safety School Toolkit, 2)

how to sign up for school heat alerts, 3) a PSA recording for schools to play, and 4) external resources.

Answers from interviewees and panelists indicate that they believe heat *school policy* plans are important, but currently the school staff feel overwhelmed with responsibilities and lack resources (time, funding, adequate support, capacity) to promote heat-protective behaviors and push heat readiness plans forward, as also encouraged by Malmquist et al. (2020) and McMullen et al. (2020). Being stretched so thin prevents school staff from taking that 'extra' step—from informal to formal guidelines and from intra- to interpersonal communication among staff and parents. To help relieve pressure, we suggest that AZ schools should connect with the ADHS to schedule a free extreme heat training webinar for your school staff and to begin utilizing their "Managing Extreme Heat Recommendations Guidance Document," as part of their job is to be available to groups who want to receive training from the public health department. Additionally, encouraging any new hire that has lived in the valley for less than a year to review the CDC training course (from ADHS School Toolkit) prior to their first day would help acclimatization to Phoenix extreme heat. Note that the most differing opinions in the literature and participant responses highlighted that school-specific needs are at the highest priority when considering school-based health interventions (McMullen et al., 2020).

Given that the Delphi survey began with 33 statements and only three were discarded, key stakeholders reached consensus (majority) that many important characteristics agree with literature that make up a HeatReady School (Hyndman, 2017). Interview responses supported literature verifying that extreme heat negatively impacts students in both *indoor and outdoor environments* (Porras-Salazar et al., 2018; Vanos, 2015; Bidassey-Manilel et al., 2016; Bytomski and Squire, 2003). Further,

classroom time and thermal comfort during outdoor play are impacted by extreme heat, further justifying the need for action planning to protect student's health from increasing temperatures.

Limitations

While these new results are a promising step forward, the small sample size is a limitation as it restricts generalizability to a broader context. Only two coders participated in this thematic analysis, which reduces the intercoder reliability of these results. In-person interviews could have potentially provided more in-depth data as removing face-to-face interaction dissipates social cues, body language, and visual context. While conducting interviews, the interviewer innately guided interviewees' responses through the semi-structured style of questions and storytelling. Though the nature of the interview was intended to be informal and more discussion-based, humans tend to be "people-pleasers"; hence, given that participants were paid for their time, they may have adjusted (even unknowingly) their responses/stories to fit with our narrative (improving heat readiness). Additionally, the author's position as a researcher shifted in the interviews to the survey, thus influencing the openness of communication and creativity between researcher to participant. In this study, the author practiced reflexivity in between interviews, in between Delphi rounds, while analyzing interview themes and survey data, and when writing. Unintended consequences of this research could include suggesting reused/unfitting recommendations or encouraging infrastructural upgrades in schools to improve thermal comfort using funds that otherwise may benefit other high priority safety/health concerns.

Conclusions

This study set out to explore 1) the current environment of heat safety culture within two elementary schools in South Phoenix, 2) the perceptions of heat from key

stakeholders in schools (and community hub), and 3) expert opinions of what characteristics make up a HeatReady School. An exploratory sequential mixed-methods case study approach was used, which focused on acquiring new insight on heat perceptions at elementary schools through semi-structured interviews using thematic analysis and the Delphi survey technique using SORT taxonomy. Results demonstrated that 1) current heat safety resources are available but not fully utilized within the school sites, 2) expert opinions further support that extreme heat readiness plans need to account for site-specific needs, particularly education as a first step, and 3) students are negatively impacted by extreme heat both inside and outside the classroom, thus these efforts are valuable.

Themes that emerged from findings will be used to create a HeatReady Schools Rubric, whereby HeatReady schools are those that are increasingly able to identify, prepare for, mitigate, track, and respond to the negative impacts of schoolground heat. HeatReady schools are a critical component of a HeatReady City; by operationalizing this Rubric, more focus is shifted towards smaller-scale action plans and boosts intra-urban connectivity, helping to make the city more resilient to heat. Results of this study demonstrated that small-scale heat readiness plans are still in the early stages of development at South Phoenix elementary schools—the ADHS, in partnership with the CDC, is presently preparing a school heat policy and recommendation document, which includes a comprehensive list of recommended actions, local background on extreme heat in schools, and suggestions for a district- or state-wide school heat policy. Data from this study will be included within and further justify the AZ school heat policy and recommendations document. It is important that resources available to schools, especially in the future, motivate people with self-efficacy—empowering and inspiring the schools to initiate and implement action to improve student overall well-being.

Efforts to make schools HeatReady is an essential step towards preparing younger generations with the tools to tackle rising temperatures from climate change.

Human Subjects Approval Statement
This protocol was approved by the ASU IRB number "STUDY00011664".

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