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Development of a Survey to Determine Why and How Exposure Occurs in Cases of Heat-Related Illness

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Master of Public Health

Global Environmental Health

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By

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B.A.
Duke University
2019

M.B.A
Emory University
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Thesis Committee Chair: Noah Scovronick, Ph.D.

An abstract of
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Abstract

Development of a Survey to Determine Why and How Exposure Occurs in Cases of Heat-Related Illness

By Kelsey Lansdale

Heat-related illness, such as heat cramps, heat exhaustion, and heat stroke, are caused by "exposure to abnormal or prolonged amounts of heat and humidity without relief or adequate fluid intake". In the United States alone, ~700 deaths per year are reported as related to heat exposure. Two reasons for the under-reporting of heat-related illness are that heat-related illnesses are not required to be reported to public health agencies, and heat-related deaths are often misclassified. The purpose of this thesis is to improve the quality of a survey for use by Emory's Climate & Health Actionable Research and Translation Center's matched case-control study to assess risk factors among patients experiencing heat-related illness requiring ED care. To substantiate the effectiveness of the survey, I conducted pilot testing with available and willing participants to 1) create a time estimate for survey completion, 2) determine areas to improve existing questions on the survey, and 3) generate a list of questions that could be a constructive addition to the survey. I tested the survey on 10 people, in a similar manner to how it will be conducted in the Emergency Department once the study official commences. To gain insight into the experience of taking the survey and determine if there were unclear questions, I created a post-survey questionnaire for the participants. I identified three themes related to confusion about questions consistent across the participants: lack of understanding of medical/academic terminology, not knowing the answer to the questions, and confusion around the scale of answer options. I suggest modifications to 25 of 91 questions and suggest seven new questions. The findings from the work will improve the final survey tool aimed at ascertaining how and why heat exposure occurred that led to the participants' heat-related ED visits.

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Heat-related illness

Definitions

Johns Hopkins Medicine describes heat-related illnesses as illnesses caused by "exposure to abnormal or prolonged amounts of heat and humidity without relief or adequate fluid intake" (Johns Hopkins Medicine). The United States Centers for Disease Control and Prevention (CDC) describes three basic forms of heat-related illnesses: heat cramps, heat exhaustion, and heat stroke (CDC, 2023). Heat cramps are the mildest form and appear as painful muscle cramps or spasms, while heat exhaustion is slightly more severe where the body is unable to cool itself properly due to inadequate fluid and salt replacement. Heat exhaustion can lead to the most severe form of heat illness, heat stroke, if left untreated. Heat stroke is life-threatening and requires medical attention immediately (CDC, 2023).

The CDC offers some information on what to look for and what to do if these different heat-related illnesses occur. Some symptoms include high body temperature, dizziness, nausea, confusion, loss of consciousness, heavy sweating, and tiredness. Some actions that can be taken to prevent or mitigate heat-related illnesses include moving the person into a cooler place, cool cloths or baths, loosening clothing, and drinking water (if it has not progressed to heat stroke) (CDC, 2023).

To determine how many cases of heat-related illness are coming into a hospital, clinicians or researchers can search for one or multiple of the eleven ICD-10 codes for heat-related illness: T67.0-, heatstroke and sunstroke; T67.1-, heat syncope; T67.2-, heat cramp; T67.3-, heat exhaustion, anhidrotic;T67.4-, heat exhaustion due to salt depletion; T67.5-, heat exhaustion, unspecified; T67.6-, heat fatigue, transient; T67.7-, heat edema; T67.8-, other effects of heat and

light; T67.9-, effect of heat and light, unspecified; and X30 Exposure to natural excessive heat (Tornese, 2023).

While there are numerous ways to code for heat-related illness, estimating the number of heat-related illnesses in the United States has proven difficult to accomplish. When a construction worker becomes disoriented from heat stroke and twists their ankle, the hospital might report the trip to the emergency room as a sprained ankle and nothing else. Additionally, instances of heat-related illnesses are not required to be reported to public health agencies and heat-related deaths are often misclassified (CDC, 2017). Overall, we are likely under-reporting heat-related illnesses in the United States (U.S. Department of Labor, 2021).

As mentioned, there are many ways to mitigate heat-related illnesses, but unfortunately ~700 deaths per year are reported as related to heat exposure (Fowler et al., 2013). Beyond heat-related deaths, the annual incidence rate for heat-related ED visits per 100,000 people was 32.24 in 2018, with the greatest visit volume in July (Dring, Armstrong, Alexander, & Xiang, 2022). Extreme heat days are associated with increased monthly adult all-cause mortality, meaning more people die monthly from any reason (not specific to heat) when there are more extreme heat days (Khatana, Werner, & Groeneveld, 2022). They also found that there was a greater increase among older adults, men, and non-Hispanic Black individuals (Khatana et al., 2022).

Why are we concerned now?

Extreme heat and heatwaves are expected to increase (IPCC, 2023). The Fifth National Climate Assessment details the effects of climate change thus far and explains that all Americans are at risk of feeling the effects of climate change. The frequency and intensity of extreme heat have increased across the entire United States with longer and hotter heatwaves (USGCRP, 2023). Furthermore, the cost and number weather-related disasters, such as heatwaves, droughts,

extreme rainfall, hurricanes, and worsened wildfires, has increased dramatically due to increasing frequency of extreme events, but also because of increases in assets at risk (USGCRP, 2023). The Lancet Countdown Report reported that in 2023 we saw the highest global temperatures in over 100,000 years (Romanello et al., 2023). There are twice as many heatwave days as there were in 1986-2005 and heat-related deaths for people over 65 years old increased by an estimated 85% compared with 1990-2000 (Romanello et al., 2023). Additionally, the increased frequency of heatwaves and droughts caused more food insecurity, which puts people at risk of malnutrition and irreversible health effects (Romanello et al., 2023).

The Lancet Countdown also found that heat exposure causing lost labor capacity led to global potential income losses of $863B and affected low and medium Human Development Index countries the most with income losses 6.1% and 3.8% of their gross domestic product (Romanello et al., 2023). Lastly, and most concerningly, the report warns that if temperatures continue to rise to just under 2°C, the yearly deaths related to heat are projected to increase by 370% by 2050. This would mean a 50% increase in heat-related labor loss and 524.9M additional people experiencing food insecurity due to heatwaves by 2041-2060 (Romanello et al., 2023). Heat-related health concerns will continue to rise as the temperature continues to rise, so we are compelled to begin acting now to determine who is most at risk, why they are at risk, and how they can adapt or be supported.

Disproportionately affected and at-risk populations

Anyone can be affected by heat in certain conditions like strenuous activity in hot weather or if there are high humidity levels, they are dehydrated, or they have sunburn, but some people are more at risk of developing heat-related illness. These people include older adults, young children, people with chronic diseases, people with low-income, athletes, outdoor

workers, and pregnant women (CDC, 2023). Additionally, people who have previously suffered a heat-related illness are at greater risk of suffering another (Stearns et al., 2020). While anyone may be at risk of heat stroke, individuals with multiple of these risks are at intensified risk (Loughnan, Carroll, & Tapper, 2014).

Older adults

Older adults are at greater risk of being affected by heat due to the body's lessoned ability to thermoregulate with age and due to different social or behavioral factors such as increased likelihood of living alone, being homebound, or taking certain medications that can affect fluid balance (Bobb, Obermeyer, Wang, & Dominici, 2014; Semenza, McCullough, Flanders, McGeehin, & Lumpkin, 1999; Semenza et al., 1996). Within the older population, there are five diseases that have elevated risks of hospitalization during heatwaves. The five diseases are fluid and electrolyte disorders, renal failure, urinary tract infections, septicemia, and heat stroke. The risks of hospitalization for these diseases are greater when the heatwaves are longer and more extreme and can remain high for one to five days after the heatwave day (Bobb et al., 2014).

Children

Children are at higher risk of heat illness than adults for a few reasons. Children have a greater surface area to body mass ratio than adults, which creates more heat exchange between the skin and surrounding environment (Bytomski & Squire, 2003). In addition, children sweat less than adults and sweating starts at a higher temperature. They also take longer to acclimatize to new temperatures and have a blunted thirst response so are less likely to drink water or replenish fluids after exercise (Bytomski & Squire, 2003). For all these reasons and more, children are at greater risk than adults for heat-related illnesses and extreme heat can cause a

significant increase in emergency department (ED) visits for children (Stowell et al., 2023; Wilk et al., 2021).

Chronic medical conditions

People with chronic medical conditions might be at greater risk of heat-related illnesses for a few reasons. They might be less able to sense/respond to changes in temperature, they might be on medications that exacerbate the effects of extreme heat, and certain conditions are risk factors for heat-related illnesses (CDC, 2023). Some specific medical conditions that compound the risks of heat-related illness include obesity, cardiovascular disease, respiratory diseases, and diabetes mellitus because these conditions hinder the body's ability to adapt to changes in the environment (Kenny, Yardley, Brown, Sigal, & Jay, 2010). Fatalities from heat stroke are 3.5 time more frequent for obese adults than in adults with average body size likely due to lower thermal sensitivity in obese individuals, lower capacity for heat dissipation, and the increased metabolic cost of weight-bearing activities (Kenny et al., 2010). Respiratory diseases, such as asthma, chronic obstructive pulmonary disease, lung cancer, influenza, pneumonia, bronchitis, tuberculosis, and cystic fibrosis, can create vulnerability to heat exposure in individuals and people with these disorders are at higher risk of death during heatwaves (Kenny et al., 2010).

Low-income

People with lower income are more at risk for heat-related illnesses for a multitude of reasons. Firstly, low-income households are significantly more heat sensitive and have lower capacity to adapt than high income households (Osberghaus & Abeling, 2022). The disproportionate heat exposures are often due to built-up neighborhoods, less vegetation, higher population density, and inability to adapt (Benz & Burney, 2021). In the summer of 1999

Chicago heatwave, a working air conditioner was found to be the strongest protective factor against heat-related death (Naughton et al., 2002). In a study in Los Angeles, California, one third of the low-income participants did not have access to air conditioning, and many of those with air conditioning elected not to utilize it due to high electricity costs (Palinkas et al., 2022).

Athletes

Heat-related death is the third leading cause of death in high school athletes in the United States (Lee-Chiong & Stitt, 1995). Football is the most dangerous sport in terms of heat as the exertional heat illness rate in football players is 11.4 times that of all other sports combined (Kerr, Casa, Marshall, & Comstock, 2013). Exertional heat-related illnesses specifically affect physically active people when exercising in high environmental heat and have their own risk factors. Some of these factors include poor physical fitness level, inappropriate clothing, stimulant-use, and aspirin-use (Nichols, 2014).

There are many ways to mitigate these risks expressly for athletes. Firstly, heat acclimatization can be an effective prevention for heat-related illness. The National Athletic Trainers' Association suggests a 14-day period for heat acclimatization in high school students. Secondly, drinking water is an easy prevention measure for athletes. Thirdly, recognition and cooling are key for parents, students, and the entire coaching staff of high school athletes ("Heat-Related Illness and Young Athletes: 3 Important Things Parents and Coaches Need to Know,").

Outdoor workers

People working outdoors are more exposed to hot environments. During 1992-2006, 68 crop workers died of heat stroke, which was an almost 20 times greater rate of heat death than all other United States workers (Luginbuhl, Jackson, Castillo, & Loringer, 2008). The United States National Institute for Occupational Safety and Health updated their recommended standard for

occupational exposure in 2016 for the maximum combination of environmental heat and metabolic heat, or workload, for workers. There is a different, higher standard with a lower temperature threshold for workers who are not acclimatized to heat, those wearing clothing that might inhibit heat dissipation, and those with personal risk factors, like medical conditions or history of heat-related illness (National Institute for Occupational Safety and Health, 2016). The CDC reviewed 25 outdoor heat-related illnesses of which 14 were fatal and 11 were non-fatal. Through this review, it was found that heat exposure limits set by the Occupational Health and Safety Administration were exceeded in all the deaths and eight of the 11 nonfatal illnesses (Tustin et al., 2018). The Heat Index limit for lower risk of heat-related illness set by OSHA is less than 91°F (when there are no other factors present), but this study found that six of the 14 deaths occurred when the Heat Index was below the limit (Tustin et al., 2018). Overall, outdoor workers are the one of the populations most vulnerable to heat-related illness, one of the most studied populations, and it seems the measures in place to maintain their safety are not effective.

Pregnant women

Pregnant women are more likely than other people to develop heat-related illnesses because their body have to work harder to cool down and they are more likely to become dehydrated (CDC, 2023). Pregnant women are at risk of preterm birth, low birth weight, and still birth when exposed to elevated temperatures (Zhang, Yu, & Wang, 2017). Mothers are also more likely to be hospitalized during pregnancy when they are exposed to extreme heat, specifically one additional day above 90°F during the first trimester (Kim, Lee, & Rossin-Slater, 2019). These hospitalizations are driven by many pregnancy complications, such as hemorrhage, early labor, and infections, some of which can be fatal to the mother and/or fetus. Interestingly, the increased hospitalization is driven by mothers living in cooler counties, contrary to what might

be expected. The hypothesized reasoning for this is that adaptation must play a significant role in heat-related illness and likelihood of hospitalization (Kim et al., 2019).

Adapting to extreme heat

According to the United States Environmental Protection Agency, there are five main ways that cities can help residents, infrastructure, and systems reduce their heat vulnerability: 1) comprehensive heat response planning, 2) forecasting and monitoring, 3) education and awareness, 4) responses to heatwaves, and 5) infrastructure improvements (United States Environmental Protection Agency, 2023). There are detailed guides available from entities such as the International Federation of Red Cross and the CDC for cities to utilize in the creation of a heat response plan (Abbinett et al.; Singh & Spires, 2019). For forecasting and monitoring, cities need to be ahead of heatwaves by using reliable weather forecasting and warning communities as early as possible to allow time for preparation. In terms of education and awareness, local officials should communicate, especially to disproportionately vulnerable groups, risk factors, symptoms, and recommended response and treatment. After educating their citizens, cities should have responses to heatwaves ready to go. These responses can include providing community cooling centers, hotline systems to alert officials about distressed individuals, encourage energy conservation, and other steps to protect residents. Lastly, local officials can help their urban cities adapt to extreme heat by improving the resilience of their infrastructure. Bridges can be built with heat tolerant or resistant materials or electrical systems can be more energy efficient to reduce stress and avoid power outages (United States Environmental Protection Agency, 2023). While we know heatwaves are worsening and causing a lot of damage around the United States, we know that there are also ways to mitigate the damage once we determine exactly what the damage is.

Climate & Health Actionable Research and Translation Center (CHART)

Due to the growing concern about extreme heat, researchers at Emory University created the CHART Center (Climate & Health Actionable Research and Translation Center). The primary objective of the Center's primary research study is to assess risk factors among patients experiencing heat-related illness who required Emergency Department (ED) care, including via a matched case-control study. Beginning in the summer of 2024, when patients are admitted to Emory University Hospital, Emory University Hospital – Midtown, or Grady Memorial Hospital for heat-related illness, study staff will ask the patients if they would be willing to participate in a survey and interview related to their background, health status, and social determinants of health. The aim of the study is to identify about 200 heat illness patients. In addition to the 200 cases, 200 controls will be selected using individual 1:1 exact matching to cases on age, sex, date of visit, and residential ZIP code. The main aims of the study are to determine who is most vulnerable, what these vulnerable people are (or are not) doing to mitigate their risks, and directly ascertain how and why exposure occurred that led to heat-related ED visits.

Aims and objectives

The purpose of this thesis is to improve the quality of the survey tool for future use by CHART study staff. To substantiate the effectiveness of the survey, I conducted pilot surveys with available and willing participants to 1) create a time estimate for conducting the survey, 2) determine areas for improvement to existing survey questions, and 3) generate a list of questions that could be a constructive addition to the survey.

Original survey

The draft survey includes branching logic, meaning follow-up questions may be asked of a participant depending on his/her initial response (Appendix 1). Due to the branching logic, the

minimum number of survey questions asked is 68, with a maximum possible amount of 91 questions. The survey was created on REDCap, a secure web platform for online databases and surveys. The survey is based on 22 pre-existing surveys asking comparable questions derived from reliable sources such as the National Institutes of Health and peer-reviewed journals (Appendix 2).

Survey testing

Over the course of fall 2023, I pilot tested the survey on 10 people. These people will not be included in the research study itself; the pilot testing was exclusively to improve the quality of the survey. Participants ranged from 25 to 85 years old, with an average age of 41.5, median age of 29.5, there were two non-native English speakers in the group, and there was an even split between men and women. I conducted each survey in a similar manner to how it will be conducted in the ED to get a more accurate account of how long it will take from start to finish. I also asked the questions exactly as they were on the REDCap to emulate a study coordinator who might not be as familiar with heat-related illness or survey administration.

Feedback on survey questions

To gain insight into participants' experience taking the survey and determine if they had any questions/concerns, I created a post-survey questionnaire for these participants (Appendix 3). Through these follow-up questions I was able to uncover which questions needed to be modified, which questions needed to be clarified, and which questions should be added. The full survey can be found in Appendix 1, while suggested modifications based on the six pilot interviews can be found in Table 1 and Table 2.

Table 1: Suggested modifications to existing survey questions based on pilot testing.

Question Number	**Original survey question**	**Original survey answer options**	**Suggested updates**

#9a	If you lived in a country outside of the United States, where did you live and for how long?	*Text answer*	Define a minimum time living outside the United States to answer yes
#23	On a scale of 1 to 5, how would you rate your risk for personal health issues during heatwaves? 1 being no heat strain at all to 5 being extreme heat strain.	1, 1- no heat strain at all 2, 2- little heat strain 3, 3- moderate heat strain 4, 4- clear heat strain 5, 5- extreme heat strain	Explain what personal health risk is
#24	Have you experienced the following symptoms or illnesses caused by heat this summer (check all the apply)?	1, Sleeping disorder 2, Fatigue 3, Anxiousness 4, Concentration issues 5, Headache 6, Immense thirst 7, Extraordinary sweating 8, Dehydration 9, Dizziness 10, Sunburn 11, Nausea 12, Vomiting 13, Wheezing 14, Difficulty breathing 15, Chest pain 16, Diagnosed sunstroke 17, Diagnosed heat stroke 18, None of the above	Define immense thirst and extraordinary sweating
#25	What kind of beverages do you usually drink on a hot day (check all that apply)?	1, Tap water 2, Mineral water 3, Coffee 4, Hot Tea 5, Iced Tea 6, Juice 7, Other 8, Don't know 99, No Response	Add “Electrolyte or sports drinks, such as Gatorade”
#27	How many glasses do you drink on a hot day?	*Integer response*	Give an example of a glass, i.e., 8oz/1 mini water bottle OR 12oz/Coca Cola can
#28b	What type of place is this?	1, Doctors' office 2, Hospital	Add “Urgent care center” as an option

		3, community clinic 4, Other 99, No Response	
#29	What kinds of health insurance or health care coverage do you have (check all that apply)?	1, Private health insurance (i.e., employee sponsored) 2, Medicare 3, Medicare supplement 4, Medicaid 5, Children's Health Insurance Program or CHIP 6, Military related health care including TRICARE, CHAMPUS, VA health care and CHAMP-VA 7, Indian Health Service 8, State-sponsored health plan 9, Other government program 0, No health insurance 99, No Response	Read out the listed options of health insurances
#33	What year was your home/building built?	*Integer response*	Add “Don’t know” as an answer
#35b	To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) that your Central AC keeps you cool enough when it is on?	1, Strongly disagree 2, Disagree 3, Somewhat agree 4, Agree 5, Strongly agree 6, Don't know 99, No Response	Change answers to: 1, Strongly disagree 2, Disagree 3, Neither agree nor disagree 4, Agree, 5, Strongly agree 6, Don’t know 99, No response
#35c	What kind of fuel does your central air conditioning system use?	1, Electricity 2, Gas, LP gas 3, Other 99, No Response	Add “Don’t know” as an answer
#39a	When do you open your windows for ventilation (check all that apply)?	1, In the morning 2, In the evening 3, At noon 4, All day 5, At night 6, Different time 7, Not sure 99, No Response	Add “In the afternoon” as an answer
#47	Do you work close to heat sources?	1, Yes 0, No 99, No Response	Add examples of heat sources

#48	Do you use PPE such as a respirator or face mask, gloves, arm and leg protection at work?	1, Yes 0, No 99, No Response	PPE should be written out as personal protection equipment
#56	Are you concerned about extreme heat?	1, Yes 0, No 99, No Response	Explain what extreme heat is Define if this means climate change or on a personal scale
#60	To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) that your neighborhood has good bus, subway, or commuter train service?	1, Strongly disagree 2, Disagree 3, Somewhat disagree 4, Somewhat agree 5, Agree 6, Strongly agree 7, Don't know 99, No Response	Change answers to: 1, Strongly disagree 2, Disagree 3, Neither agree nor disagree 4, Agree, 5, Strongly agree 6, Don’t know 99, No response
#61	How many times per week do you take public transportation? Would you say...	0, Never 1, A few times a year 2, A few times a month 3, A few times a week 4, Most of the week (5 days) 5, Every day 99, No Response	Rephrase the question to ask “How often do you take public transportation? Would you say…”
#65	Lastly, I’ll ask you some questions about your neighborhood. To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) with the following statements?	1, Strongly disagree 2, Disagree 3, Somewhat agree 4, Agree 5, Strongly agree 6, Don't know 99, No Response	Change answers to: 1, Strongly disagree 2, Disagree 3, Neither agree nor disagree 4, Agree, 5, Strongly agree 6, Don’t know 99, No response
#67	To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) with the following statements about your neighborhood and the people who live there? You may also select 'no opinion.'	1, Strongly disagree 2, Disagree 3, Somewhat agree 4, Agree 5, Strongly agree 6, Don't know 99, No Response	Change answers to: 1, Strongly disagree 2, Disagree 3, Neither agree nor disagree 4, Agree, 5, Strongly agree 6, Don’t know 99, No response

Table 2: Suggested questions to add.

Additional survey questions
Are you currently pregnant?
Do you believe you have ever suffered from a heat-related illness? Was this heat-related illness diagnosed? Why or why not did you seek care? Why did you think you were having a heat-related illness?
Are you aware of anyone else in your neighborhood outside your household been diagnosed with heat stroke this summer?
Has anyone else in your household been diagnosed with heat stroke this summer?

While speaking to these participants, some themes of confusion arose, as can be seen in Table 1 and Table 2. One theme that emerged was lack of understanding of medical/academic terminology. This can be seen in questions #23, #24, #29, #47, and #56 with one question I received from multiple participants being "Does extreme heat mean global warming or a really hot day as I might experience?". Another theme that emerged was respondents not knowing the answer to questions (as seen in questions #33 and #35c) or over half the respondents giving a specific response to a question where their response was not one of the listed options (as seen in questions #25, #28b, and #39a). Another comment I received from all 10 of the participants was that the questions utilizing bipolar Likert scale responses, meaning a rating scale measuring their opinions on a topic, were not uniform and did not provide a complete spectrum. An example of this issue is question #60, where respondents were given the options of 1, Strongly disagree; 2, Disagree; 3, Somewhat disagree; 4, Somewhat agree; 5, Agree; and 6, Strongly agree. A respondent answered, "I feel neither like my neighborhood has a good public transportation system nor a poor public transportation system. I wish there were an option that was neutral." Because of the consistent feedback from participants, I am suggesting that to allow a full

spectrum of opinions, all Likert scale responses be updated to the following 1, Strongly disagree; 2, Disagree; 3, Neither agree nor disagree; 4, Agree; and 5, Strongly agree.

Survey time to completion

Beyond the updated questions to the survey, I was also testing for time to completion. The average time to complete the entire survey was a little over 15 minutes total (Figure 1). The longest time taken to complete the survey was almost 25 minutes, and the minimum time was 11 minutes, with the average 14 minutes and 48 seconds and the median time 14 minutes and 8 seconds. Three of the questions using branching logic (questions #34a, #35a, and #36a) were not tested as none of the participants answered in the way that caused those questions to be activated. Since these are all multiple-choice questions where the answers are not read aloud, I hypothesize they would not add more than 30 seconds a piece to the survey time.

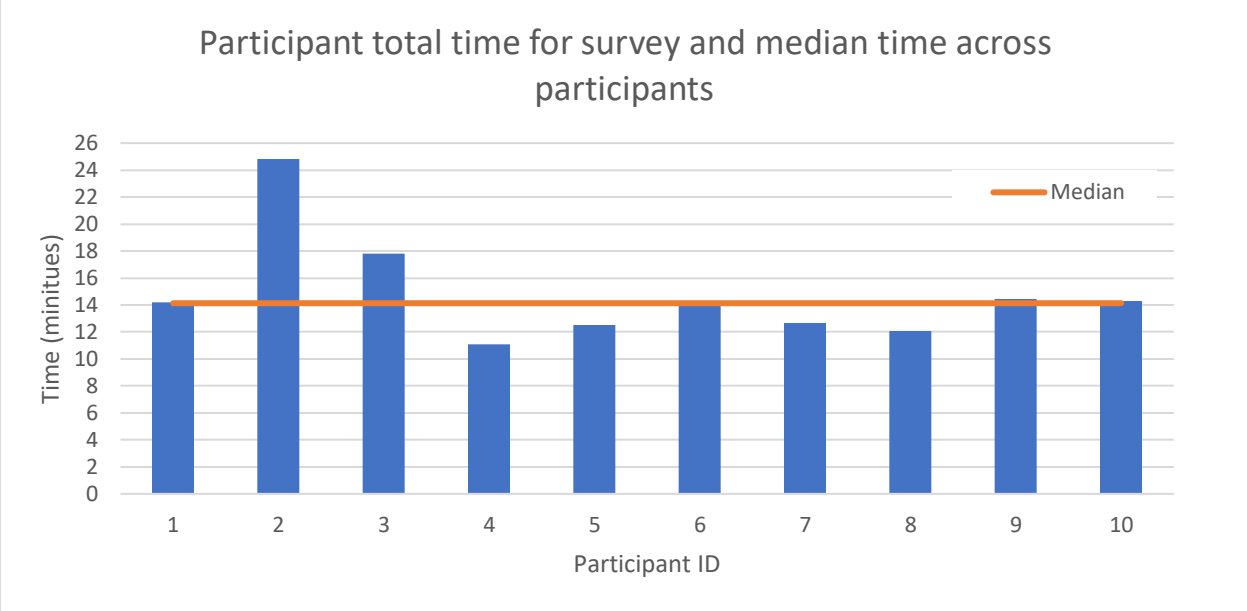

Figure 1: Time to complete the full survey for each participant, and median time to completion across participants.

Beside completion from start to finish, I also looked at the time to complete each of the eight sections: 1) questions about self, 2) health status, 3) social determinants of health, 4)

financial burden, 5) occupation, 6) heat, 7) getting around, and 8) neighborhood. Section 2 (health status) took the longest on average to complete (Figure 2).

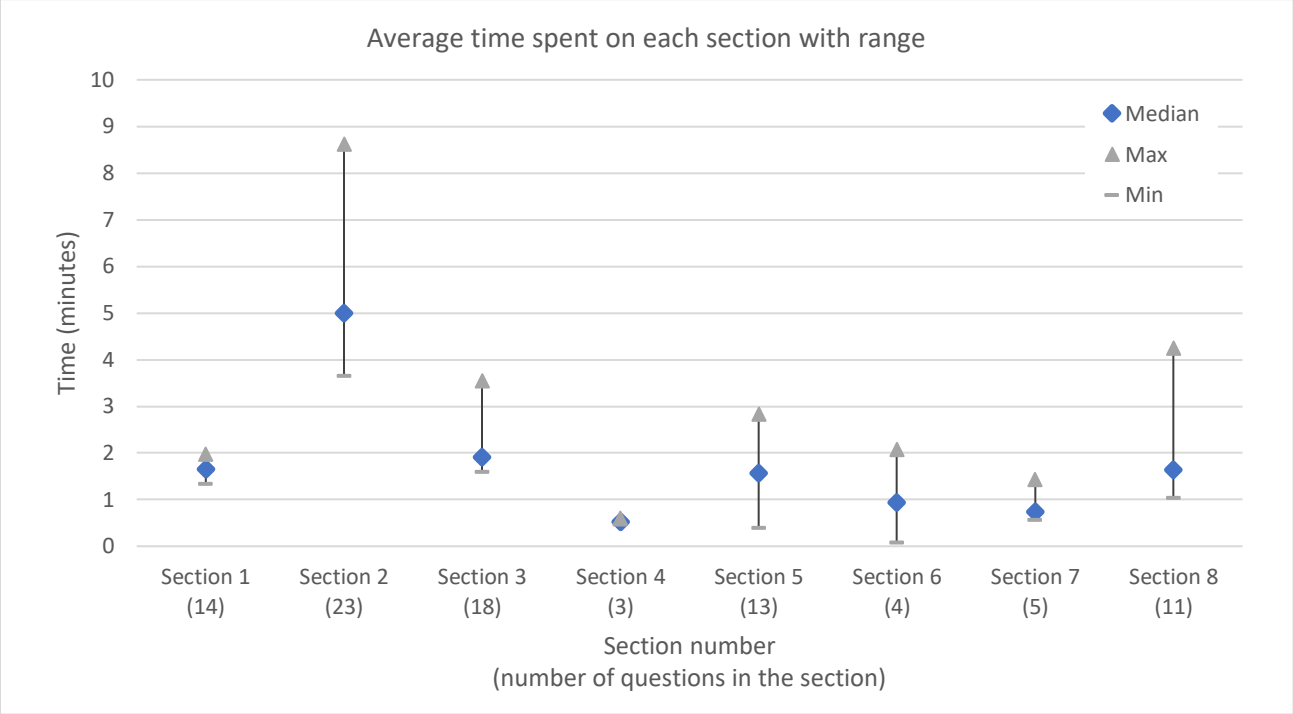

Figure 2: Average time to complete each section and number of questions per section.

Section 2 is the longest with a maximum of 23 and a minimum of 20 questions. Additionally, section 2 is one of the most personal as it relates to health status, chronic conditions, and prescriptions, and because of that people with more medical history to share took longer than others.

Discussion and Limitations

Through testing and analysis of pilot survey participants, the draft survey being developed for the CHART research project has been improved and expanded. By analyzing themes of confusion from participants, either through asking follow-up questions or reading their body language, I was able to assess which survey questions needed to be adapted for optimal patient understanding.

Of course, there are limitations to my methodology. Some of the limitations include that this was a small population. In addition, the survey participants utilized for this pilot study might not represent well the patients admitted to the target hospitals. The pilot was conducted on relatively healthy and mostly young individuals where we expect those coming into the ED to be older and less healthy, on average. Additionally, the pilot population mostly had private health insurance whereas about 12% of the residents Grady serves in their counties are uninsured and almost 10% of the population in their service area are 25+ years old without a high school diploma (*Community Health Needs Assessment*, 2022).

There may be additional areas to streamline section 2 that should be explored as it had the widest range and the largest median time to completion by more than double the time it took to complete the next longest section. Through conversation with the participants and my own research, I suggested the addition of four questions, one of which has three branching questions based on their response. Firstly, in the health section, a question on if the participant is currently pregnant should be added to determine if they were already at higher risk of heat-related illness. Secondly, also in the health section, participants should be asked if they think they have suffered from a heat-related illness in the past, as they could be at greater risk for recurrent heat-related illnesses. The branching logic from this question will determine if it was diagnosed, why they chose or did not choose to seek care, and what symptoms they may have suffered. The final two questions will give more insight into their environment by asking if anyone in their household or neighborhood had suffered from a heat stroke. These questions will add valuable understanding of the participants' vulnerability to heat-related illness.

The pilot surveys I conducted led to a time estimate for conducting the survey (between 11 minutes and 25 minutes, but expected to be about 15 minutes), clear areas of quality

improvement to existing questions, and gaps in the survey to ascertain how and why exposure occurred that led to the participants' heat-related ED visits. The main themes of confusion were not understanding medical/academic jargon, not knowing the answer to the question being asked, and wanting a consistent and full spectrum of options when asked about their opinions. I have suggested modifications for 25 of the 91 total survey questions that I believe will minimize confusion and maximize the participants' experience. Furthermore, based on my research and feedback from pilot participants, I have suggested an addition of seven new questions to the survey regarding the participants risk of having a heat stroke either because of personal risk factors (pregnancy or previous heat stroke) or environmental risk factors (if anyone else in their neighborhood or household has suffered from a heat stroke).

While this pilot survey led to many suggested modifications and additions, there is always more work that could be done to further improve the survey. One future direction that should be considered is pilot testing the survey at the target hospitals. This would allow for testing amongst the target patient population and under the conditions that the participants will be, such as in the ED. Additionally, the survey should be tested on more people that are likely to suffer heat-related illness, such as older people, people who work outdoors, low-income people, and pregnant women.

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Appendix 1: Original Survey

Survey Guide

Mapping Risk factors for Heat-Related Illness Emergency Department Visits

Instructions for Survey Guide

- All interviewer instructions and actions will be in italicized capital letters between parentheses. Do not read these aloud to the respondent.
    - Ex. *(PAUSE FOR RESPONSE)*
- All lines to be read to the respondent will be in sentence-case and have no font modifications (will NOT be underlined, italicized, or bolded).
    - Ex. Before we begin, are there any questions?
- For Yes or No questions, the survey administrator will not read the responses (i.e., Yes and No)
- For questions with multiple response options, the survey administrator will follow the instructions given.
    - *(READ ALL RESPONSES)* indicates that the administrator will read the given response options aloud to the participant
    - *(DO NOT READ RESPONSES)* indicates that the administrator will not read the given response options aloud to the participant. Instead, they will choose the option the participant gives.

Mapping Risk factors for Heat-Related Illness Emergency Department Visits Survey

Thank you for taking the time to complete our survey. Before we begin, I'd like to let you know a few things about this survey. Responses to this survey will not go into any of your clinic records. Your survey will be identified through a study ID number, so it will not have your name written on it. Your answers to these questions will not be published individually but will be reported in aggregate form (for example, we might report the percentage of people who gave a particular answer to a question). If you do not feel comfortable answering any of the questions in this survey, just let me know and we will move on. Do you have any questions about the survey before we begin? *(PAUSE FOR RESPONSE)*

Background:

First, I will ask you some questions about yourself. Are you ready to begin? *(PAUSE FOR RESPONSE)*

1. What is your age? _____
2. What is your gender (check one)? *(DO NOT READ RESPONSES)*
    a. Female
    b. Male
    c. Nonbinary
    d. Other
3. What is your race (check one)? *(DO NOT READ RESPONSES)*
    a. American Indian or Alaska Native
    b. Asian
    c. Black or African American
    d. Native American or Pacific Islander
    e. White
    f. More than one race
    g. Other
4. Are you of Hispanic, Latino/a, or Spanish origin (check one)? *(DO NOT READ RESPONSES)*
    a. Yes
    b. No
5. What is your height in feet and inches? _____
6. What is your weight in pounds? _____
7. Were you born outside of the United States?
    a. Yes
    b. No

7a. If yes, in which country were you born? _____

8. Have you lived in a state outside of Georgia?
   a. Yes
   b. No

8a. If yes, where did you live and for how long? _____

9. Have you lived in a country outside of the United States?
   a. Yes
   b. No

9a. If yes, where did you live and for how long? _____

10. Is English your first language?
   a. Yes
   b. No

10a. What language do you speak primarily at home? _____

Health Status:

Next, I will ask you some questions about your health. As a reminder, you do not have to answer any questions that make you uncomfortable.

11. In general, would you say your health is: *(READ ALL RESPONSES)*
   a. Excellent
   b. Very good
   c. Good
   d. Fair
   e. Poor

12. Do you have difficulty walking or climbing steps? Would you say: *(READ ALL RESPONSES)*
   a. I have no difficulty
   b. I have some difficulty
   c. I have a lot of difficulty
   d. I cannot do this at all

13. Do you use any of the following (check all that apply)? *(READ ALL RESPONSES)*
   a. Wheelchair or scooter
   b. Cane or walker
   c. Someone's assistance
   d. None of the Above

14. How often do you have difficulty remembering? Would you say: *(READ ALL RESPONSES)*

a. Never
b. Sometimes
c. Often
d. All of the time

15. How often do you have difficulty concentrating? Would you say: *(READ ALL RESPONSES)*

a. Never
b. Sometimes
c. Often
d. All of the time

16. How often do you feel worried, nervous or anxious? Would you say: *(READ ALL RESPONSES)*

a. Daily
b. Weekly
c. Monthly
d. A few times a year
e. Never

16a. Do you take prescription medication for these feelings?

a. Yes
b. No

17. Has any health professional ever told you that you had any of the following chronic conditions (check all that apply)? *(READ ALL RESPONSES)*

a. High blood pressure
b. Heart disease
c. Diabetes
d. Cancer or any malignancy
e. Asthma
f. Kidney disease
g. Broken bone or fracture
h. Foot ulcer or amputation
i. High cholesterol (hyperlipidemia)
j. None of the above

18. Has your doctor or nurse ever told you that your health problem can make you more sensitive to the heat?

a. Yes
b. No
c. Not sure

19. Some medications affect the body's ability to regulate temperature. Could you tell me which prescription or over the counter medications (if any) you are currently taking?
_____

20. On average, how many hours do you sleep per night? _____

21. During the past month, how would you rate your sleep quality overall: *(READ ALL RESPONSES)*
a. Excellent
b. Very good
c. Good
d. Fair
e. Poor
f. Don't know

22. Are there specific things in your environment that disrupt your sleep (e.g., noise, temperature, neighbors)?
a. Yes
b. No

22a. If yes, what are those sleep disruptions? _____

23. On a scale of 1 to 5, how would you rate your risk for personal health issues during heatwaves? 1 being no heat strain at all to 5 being extreme heat strain. *(DO NOT READ RESPONSES)*
a. 1- no heat strain at all
b. 2- little heat strain
c. 3- moderate heat strain
d. 4- clear heat strain
e. 5- extreme heat strain

24. Have you experienced the following symptoms or illnesses caused by heat this summer (check all the apply)? *(READ ALL RESPONSES)*
a. Sleeping disorder
b. Fatigue
c. Anxiousness
d. Concentration issues
e. Headache
f. Immense thirst
g. Extraordinary sweating
h. Dehydration
i. Dizziness
j. Sunburn
k. Nausea
l. Vomiting
m. Wheezing

n. Difficulty breathing
o. Chest pain
p. Diagnosed sunstroke
q. Diagnosed heat stroke
r. None of the above

25. What kind of beverages do you usually drink on a hot day (check all that apply)? *(DO NOT READ RESPONSES)*
a. Tap water
b. Mineral water
c. Coffee
d. Hot tea
e. Iced Tea
f. Juice
g. Other
h. Don´t know

26. Do you drink more fluids on hot days?
a. Yes
b. No
c. Don't know

27. How many glasses do you drink on a hot day? _____

28. About how long has it been since you last saw a primary care doctor or other health professional for a. physical or general-purpose check-up? Has it been: *(READ ALL RESPONSES)*
a. Within the past year
b. Between 1-5 years ago
c. Longer than 5 years ago
d. Not sure

28a. Is there a place that you USUALLY go to if you are sick and need health care?
a. Yes
b. No

28b. If yes, what type of place is this? *(DO NOT READ RESPONSES)*
a. Doctors' office
b. Hospital
c. Community clinic
d. Other _____

29. What kinds of health insurance or health care coverage do you have (check all that apply)? *(DO NOT READ RESPONSES)*
a. Private health insurance
b. Medicare

c. Medicare supplement
d. Medicaid
e. Children's Health Insurance Program or CHIP
f. Military related health care including TRICARE, CHAMPUS, VA health care and CHAMP-VA
g. Indian Health Service
h. State-sponsored health plan
i. Other government program
j. No health insurance

Social Determinants of Health:

Next, I will ask you some questions about your home.

30. What is your residential address? _____

31. Is [address] a house, apartment, or other? *(DO NOT READ RESPONSES)*
a. House
b. Condominium
c. Apartment
d. Long-term care facility
e. Mobile or manufactured home
f. I am staying with others
g. I am staying in a hotel
h. I am staying in a car
i. I am not currently housed
j. Other

32. Do you, or your spouse or partner, own this [type of residence], rent, or other? *(DO NOT READ RESPONSES)*
a. Rented
b. Owned
c. Live here for free
d. Other
e. Don't Know

33. What year was your home/building built? _____

34. Do you have functioning air conditioning anywhere in your home? If so, what kind? [Select all that apply] *(DO NOT READ RESPONSES)*
a. No (go to 34a)
b. Yes, Window AC (Skip to #35)
c. Yes, Wall AC (Skip to #35)
d. Yes, Portable AC (Skip to #35)
e. Yes, Central AC (Skip to #35)

34a. Why don't you have air conditioning (check all that apply)? *(DO NOT READ RESPONSES)*

a. You don't need it
b. It's too expensive
c. You want to conserve electricity
d. Your building's wiring is not equipped to run an AC
e. You don't like air conditioning
f. Building owner does not allow
g. Don't know
h. Other

35. Do you use the central air conditioning?

a. Yes (go to 35b)
b. No (go to 35a)

35a. Why don't you use the central air conditioning (check all that apply)? *(DO NOT READ RESPONSES)*

a. You don't need it
b. It's too expensive
c. You want to conserve electricity
d. Your building's wiring is not equipped to run an AC
e. You don't like air conditioning
f. Building owner does not allow
g. Don't know
h. Refused
i. Other: _____

35b. To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) that your Central AC keeps you cool enough when it is on? *(READ ALL RESPONSES)*

1. Strongly disagree
2. Disagree
3. Somewhat agree
4. Agree
5. Strongly agree
6. Don't know

35c. During a typical week last summer, how often did someone in the household use central air conditioning? Would you say… *(READ ALL RESPONSES)*

1. Always
2. Most days of the week
3. About half the days of the week
4. Less than half the days of the week
5. Never
8. Don't know
9. Refused

35d. What kind of fuel does your central air conditioning system use? *(DO NOT READ RESPONSES)*

1. Electricity
2. Gas, LP gas
3. Other

36. This summer, for any reason, was your home so hot for 24 hours or more that you were, or another household member was, uncomfortable?

a. Yes (go to 35a)
b. No (go to 36)

36a. Why was it so hot (check all that apply)? *(DO NOT READ RESPONSES)*

a. Utility Interruption
b. The AC or fan wasn't strong enough to cool
c. Inadequate insulation, includes inadequate window insulation
d. Cost of cooling
e. Other

37. How would you describe typical living conditions in your residence during this SUMMER? *(READ ALL RESPONSES)*

a. Hot
b. Warm
c. About right
d. Cool
e. Cold
f. Don't know

38. Do you use a fan in your home to cool down?

a. Yes
b. No

39. Do you open the windows of your apartment / house for ventilation when it's hot?

a. Yes (go to 38a)
b. No (go to 38b)

39a. When do you open your windows for ventilation (check all that apply)? *(DO NOT READ RESPONSES)*

a. In the morning
b. In the evening
c. At noon
d. All day
e. At night
f. Different time
g. Not sure

39b. Why don´t you open the windows for ventilation? _____

Next, I'm going to ask you some questions about the financial burden of keeping your home running. As a reminder, you don't have to answer if you don't feel comfortable.

40. In the last 12 months, did you have trouble paying your utility (gas, electricity, water) bills or did the electric, gas, or water company threaten to shut off your services?
   a. Yes
   b. No

41. At the present time, how easy or difficult is it to pay your bills? Would you say it is… *(READ ALL RESPONSES)*
   a. Very difficult
   b. Difficult
   c. Neutral
   d. Easy
   e. Very easy
   f. Refuse to answer

42. Do extreme temperatures impact your decision about which bills to pay?
   a. Yes
   b. No

Thank you for your time so far. Next, I'll ask some questions about your occupation and your other activities.

43. Have you done any work for pay in the past 12 months?
   a. Yes
   b. No (skip to 53)

44. What is your occupation? _____

45. Which best describes your workplace environment? Is it… *(READ ALL RESPONSES)*
   a. Completely indoors
   b. Mainly indoors
   c. Completely outdoors
   d. Mainly outdoors
   e. Other

46. Is your work physically demanding? Would you say… *(READ ALL RESPONSES)*
   a. Not at all
   b. A little bit
   c. Moderately
   d. Very much

47. Do you work close to heat sources?
   a. Yes

b. No

48. Do you use PPE such as a respirator or face mask, gloves, arm and leg protection at work?
   a. Yes
   b. No

49. Have you experienced or witnessed a heat-related injury at work?
   a. Yes
   b. No

50. Have you participated in heat-related training in the workplace?
   a. Yes
   b. No

51. Are you satisfied with the current heat prevention measures in place in your workplace?
   a. Yes
   b. No

52. Other than through your work, do you regularly spend time outdoors?
   a. Yes
   b. No

53. How much time in hours do you usually spend outside per week? _____

54. What activities do you do outside? _____

55. When it is hot, do you change your time spent outdoors?

   a. Yes
   b. No

Now, I'll ask you some questions about heat.

56. Are you concerned about extreme heat?
   a. Yes
   b. No
   c. Not sure

57. What are the symptoms of heat stroke? _____

58. What do you do when it is very hot to protect yourself? _____

59. Does your household have a plan to protect yourself in the event of heat wave? This might include how to contact your family members or how to leave your home.
   a. Yes

b. No

Next, I'll ask you some questions about how you get around.

60. To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) that your neighborhood has good bus, subway, or commuter train service? *(DO NOT READ RESPONSES)*
   a. Strongly disagree
   b. Disagree
   c. Somewhat disagree
   d. Somewhat agree
   e. Agree
   f. Strongly Agree
   g. Don't know

61. How many times per week do you take public transportation? Would you say… *(READ ALL RESPONSES)*
   a. Never
   b. A few times a year
   c. A few times a month
   d. A few times a week
   e. Most of the week (5 days)
   f. Every day

62. What is your normal mode of transportation (to work, for groceries)? *(DO NOT READ RESPONSES)*
   a. Car
   b. Public Transportation
   c. Ride Share
   d. Walk
   e. Bike
   f. Other

63. In the past 12 months, has a lack of reliable transportation kept you from medical appointments, meetings, work, or from getting things you needed for daily living?
   a. Yes
   b. No

64. Do you change your normal mode of transportation when it is hot?
   a. Yes
   b. No

Lastly, I'll ask you some questions about your neighborhood.

65. To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) with the following statements? "Green space" is any area with natural vegetation. This can include parks, yards, grassy areas, street trees, green roofs, cemeteries, etc.

a. There is a lot of vegetation/greenery in my neighborhood
b. I can see vegetation/greenery from my home
c. The nearest vegetated park/green space is easy for me to access
d. I spend a lot of time in spaces with natural vegetation
e. The green spaces near my home are very high in quality

66. How concerned are you about crime in your neighborhood? *(READ ALL RESPONSES)*

a. Not at all concerned
b. A little concerned
c. Very Concerned

67. To what extent do you agree (strongly disagree, disagree, agree, and strongly agree) with the following statements about your neighborhood and the people who live there? You may also select 'no opinion.'

a. People are willing to help their neighbors.
b. This is a close-knit neighborhood.
c. People in this neighborhood can be trusted.
d. People in this neighborhood don't get along with each other.

68. How confident do you feel that you have 1 or more local friend(s) and/or family member(s) that would help you if you developed heat stroke or other heat-related illness? *(READ ALL RESPONSES)*

a. Very confident
b. Somewhat confident
c. Not too confident
d. Not confident at all

Thank you so much for taking the time to complete this survey.

Appendix 2: All other surveys drawn from for the design of our survey.

Survey Name/Manuscript	Owner/Author	Year
	National Institutes of Health	
Motivation for Heat Adaption: How Perception and Exposure Affect Individual Behaviors During Hot Weather in Knoxville, Tennessee	Hass AL, Ellis KN	2019
American Housing Survey (2021, 2022, 2023, 2024)	United States Census Bureau	2021-2024
National Health Interview Survey	United States Census Bureau – CDC	2023
National Health Interview Survey-Cognition	United States Census Bureau – CDC	2023
National Health Interview Survey-Anxiety	United States Census Bureau – CDC	2023
The Hopkins Sleep Survey	Johns Hopkins University	
Mixed methods assessment of personal heat exposure, sleep, physical activity, and heat adaptation strategies among urban residents in the Boston area, MA	Milando CW, Black-Ingersoll F, Heidari L, et al	2022
Original mixed methods research-Reducing the risks of extreme heat for seniors: communicating risks and building resilience. Health Promotion and Chronic Disease Prevention in Canada: Research, Policy and Practice	Eady A, Dreyer B, Hey B, Riemer M, Wilson A.	2020
Perceptions of green space usage, abundance, and quality of green space were associated with better mental health during the COVID-19 pandemic among residents of Denver.	Reid CE, Rieves ES, Carlson K.	2022
Urban Green Space Perception and Its Contribution to Well-Being	Kothencz G, Kolcsár R, Cabrera-Barona P, Szilassi P	2017
Perceptions of	Han SR, Wei M, Wu Z, Duan S, Chen X, Yang J,	2021

workplace heat exposure and adaption behaviors among Chinese construction workers in the context of climate change	Borg MA, Lin J, Wu C, Xiang J	
Perceptions of heat-health impacts and the effects of knowledge and preventive actions by outdoor workers in Hanoi, Vietnam.	Lohrey S, Chua M, Gros C, Faucet J, Lee JK	2021
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Appendix 3: Post-survey questionnaire

Post-survey questionnaire

Questions to be answered by participant:

1. Were there any questions that were confusing/difficult to understand?
2. Were there any questions that you felt like were missing from the survey?

Questions to be answered by interviewer:

1. Time during each section
    a. Questions about self
    b. Health status
    c. SDOH
    d. Financial burden
    e. Occupation
    f. Heat
    g. Getting around
    h. Neighborhood
2. Questions that arose during the survey/points of confusion
3. Questions that led to stories/long answers