

The social impacts of the heat–health watch/warning system in Phoenix, Arizona: assessing the perceived risk and response of the public

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Abstract Heat is the leading weather-related killer in the United States. Although previous research suggests that social influences affect human responses to natural disaster warnings, no studies have examined the social impacts of heat or heat warnings on a population. Here, 201 surveys were distributed in Metropolitan Phoenix to determine the social impacts of the heat warning system, or more specifically, to gauge risk perception and warning response. Consistent with previous research, increased risk perception of heat results in increased response to a warning. Different social factors such as sex, race, age, and income all play an important role in determining whether or not people will respond to a warning. In particular, there is a strong sense of perceived risk to the heat among Hispanics which translates to increased response when heat warnings are issued. Based on these findings, suggestions are presented to help improve the Phoenix Heat Warning System.

Keywords Heat · Weather warnings · Weather · Climate · Perception

Introduction

The Centers for Disease Control estimate that from 1979 through 1999, 8,015 deaths were directly caused by the heat

(Centers for Disease Control 2002). However, the actual total is much higher since extreme heat results in increased mortality for many other causes of death, such as cardiovascular and respiratory disease (Shen et al. 1998; Kilbourne 1997). The 1995 heat wave in Chicago was responsible for over 800 deaths alone, and estimates for the 2003 heat wave across Europe range from 22,000 to upwards of 50,000 deaths (Whitman et al. 1997; WHO 2004; Brucker 2005).

As a result of these recent disasters, a large amount of research has begun to focus on heat and its impacts on humans. Furthermore, a new heat warning system has been developed based upon actual human health responses to the heat. However, despite the increase in heat–health research, there have been very few studies examining the social response to heat and heat warnings. For example, how does the public perceive heat and are they aware that heat can be an extremely dangerous weather-related phenomenon? What is the public response to extreme heat conditions or a National Weather Service (NWS) heat warning? Do people alter their daily habits as a result? How concerned is the public about heat; do they feel threatened or worried? These are all vital questions, since previous research has shown that perceived risk from a threat often leads to action to help mitigate potential consequences.

Perceived risk

Research has suggested that perception of risk and mitigating action are closely related, and Janis (1962) provides an interesting counter-example. An event is examined in which people were killed by carbon monoxide, an odorless, colorless, but extremely dangerous gas. Although some warning signs existed such as nausea and dizziness, people did not respond immediately since the

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threat was “highly ambiguous” and because the danger signs appeared when people were not expecting danger. Janis (1962) concludes that this unusual combination of circumstances is what led to the disaster. Not surprisingly, heat can act in a very similar fashion, especially in Phoenix, where the population can be lulled into a false sense of security by afternoon temperatures that average over 103°F (39.4°C) throughout much of the summer. The threat of heat seems ambiguous, and many people perceive little or no threat from it since, as many Phoenix residents report, “it always seems hot in the summer.”

Perry and Lindell (1997) note that a large amount of research has been conducted on human responses during and following disasters while very little research exists examining responses to disaster warnings. However, of the research that has been conducted on warnings, most scientists agree that the leading factor that dictates behavior is a perceived risk (Sims and Baumann 1983; Janis 1962; Perry et al. 1982).

Perceived risk to a disaster can best be obtained in two ways: (1) education, and (2) personal experience with the disaster (Vitek and Berta 1982). Often, due to a lack of education, people are simply unaware that they are at risk for a natural disaster and do not realize they are in danger (O’Riordan 1986). As a result, when disaster does strike, most people do not take action and are surprised or caught off guard. Even worse, those who are uneducated about the disaster often conclude that it could not happen again, thus putting themselves at unnecessary risk for a future event (Vitek and Berta 1982).

Janis (1962) notes that people are more likely to respond to a warning if someone they know has been previously affected by the disaster. This personal experience with the disaster tends to reduce apathy, indifference, wishful thinking, and denial, all of which can lead to an under-reaction to a warning. Furthermore, a personal experience with the disaster allows a warning to be reinforced socially, through friends, neighbors, and community networks (Perry and Lindell 1997). Sims and Baumann (1983) note that “while people get information from the media, that information is given meaning and importance through being processed by friends and neighbors,” thus leading to increased risk perception and an increased likelihood of responding to a warning.

The media also play an important role in the public perception of disasters, and Hiroi et al. (1985) suggest that the media tend to exaggerate damage in disasters. As a result, the public often believes that more people die from natural disasters than is actually true (Whyte 1986). However, this pattern seems to be reversed when it comes to heat; both the public and the scientific community have a consistent pattern of under representing the actual impacts of heat. For example, in a recent article specifically about

the progress of natural disaster warning systems across the United States, Sorensen (2000) examines 12 disaster warning systems. Surprisingly, heat is not among them despite the fact that it has been shown to be the leading weather-related killer in the United States (Sheridan and Kalkstein 2004). Perhaps this general disregard for heat in both academia and the public is partially due to lack of media reporting. Heat has been called the “silent killer” in that it lacks the “awe” factor associated with other natural disasters. As Sandman (1994) notes, “journalists are in the news business, not the education business or the health protection business”, and this could be a possible cause of the apparent perception that heat is not among the most severe or dangerous natural disasters.

Risk response

The public response to a natural disaster warning is surprisingly complex and, often, the human response to a warning is not as expected. It has been shown that even if the public is informed of a risk and knows what to do, it will often not do it. However, “sometimes, under highly specified conditions, and if properly executed, with certain target publics, information may lead to awareness and awareness may lead to behavior” (Sims and Baumann 1983). Thus, the question is: what exactly are the specified conditions, properly executed, with certain target audiences that may lead to a public response to a warning?

First, Mogil (1980) notes that the terminology of the warning is extremely important. The ideal warning will describe the hazard, its probable time of impact, and will then suggest appropriate adaptive behaviors. Furthermore, more specific messages tend to produce an increased level of warning belief and, thus, warning response (Perry et al. 1982). Warnings must also be clear and perceived as emanating from a credible source (Sims and Baumann 1983).

Next, there needs to be a clear connection between the threat and what someone is supposed to do about it. Withey (1976) notes that a person is more likely to respond to a warning if the message clearly states what adaptive behavior is required. However, if the warning provides no way to substantially reduce or eliminate the threat, the population is much less likely to act (Withey 1962).

Research has also shown that the public is often skeptical of warnings, and only a small percentage of the population takes action when the NWS issues a warning (Carter 1980). This could be partially due to the “cry wolf effect”, in that many people think the NWS over-warns for weather-related disasters (Mogil 1980). Furthermore, Atwood and Major (1998) suggest that if a warning expires without a disaster, both protective behavior and the perceived importance of the threat decrease. Initial warn-

ings have been associated with increased anxiety and a higher likelihood of a response, while repeated warnings result in less perceived risk (Hansson et al. 1982). Even more confusing is the fact that threats by officials about the disaster are often ineffective, but, ironically, explicit statements by officials minimizing the risk such as “don’t worry” were often found to be more alarming (Sandman 1994). Finally, Sims and Baumann (1983) conclude that to elicit the greatest warning response from the public, officials must “convince the skeptics” that there is a real and credible threat. Unfortunately, this can be exceedingly difficult because, according to Sims and Baumann (1983), “people want intellectual closure; thus, once opinions are formed (regardless of the representativeness of the evidence on which they are based), they tend to become fixed and new evidence is made to conform even if it requires considerable distortion.”

Recent technologies have allowed scientists to better predict natural disasters and, thus, have led to more effective warnings systems. Sorensen (2000) documents these improvements for numerous warning systems (heat is not included) over a 20-year span beginning in the late 1970s. He suggests that there have been “major” improvements in hurricane forecasts and the integration of these forecasts into warnings. Despite these improvements, recent disasters such as Hurricane Katrina illustrate that, despite better technology, many people still cannot or do not heed the warning. Perhaps with the devastation observed with Hurricane Katrina, people will be more likely to take action in the future.

It is important to note that various portions of the population are more likely to heed warnings than others, and age, gender, and ethnicity are all important factors in warning response (Perry and Lindell 1997). Perry et al. (1982) suggest that death rates for minorities are higher than those for Whites during natural disasters. To support their findings, they note that, in one case, Mexican-Americans were more skeptical about believing warning messages. Furthermore, Mexican-Americans interpreted the same warning messages as indicating lower levels of personal danger and, thus, they were less likely to take protective action. Also, minorities tend to be more fearful of technological disasters such as a nuclear radiation leak, while Whites are generally more concerned about natural disasters (Vaughan and Nordenstam 1991). It is likely the racial differences in risk perception and response are partially due to varying life experiences, such as increased exposure to poverty or crime, which cause many to become more fearful of a man-made disaster. Finally, despite the fact that many believe the elderly are less likely to respond to a warning, Perry and Lindell (1997) find otherwise and note that “age alone is not a useful predictor of warning compliance.” In fact, they find that in certain cases, the

elderly sometimes respond in higher percentages than other age groups.

Heat warning system

To help protect citizens from the negative health impacts associated with extreme heat, many NWS offices across the United States have implemented a heat warning system. Most of these systems issue excessive heat warnings based upon the following criteria: “if the heat index is expected to exceed 105–110°F (40.5–43°C) (depending on local climate) for at least two consecutive days” (National Weather Service 2006). However, there are several problems with these guidelines. First, the thresholds for calling warnings are arbitrary; there have been no studies suggesting that human health begins to deteriorate above a 105°F heat index. Next, the same thresholds are applied for numerous cities across the United States despite the fact that human responses to a 105°F heat index would be very different in places such as Chicago and Atlanta (Kalkstein et al. 1996b).

Beginning in 1995, the NWS began implementing a new heat warning system, which was adopted by the Phoenix NWS Office in the summer of 2002 (Sheridan and Kalkstein 2004). This warning system is based upon the identification of “oppressive” air masses, which have been associated with increases in human mortality. A Spatial Synoptic Classification is used to place each day at a specific location into one of eight different air mass types, based upon the location’s temperature, dew point, cloud cover, wind direction and wind speed (Kalkstein et al. 1996a; Sheridan 2002). In Phoenix, two particularly hot subsets of the dry tropical air mass were found to be correlated with increases in human mortality, and the Phoenix heat warning system is based upon the occurrence of these two oppressive air masses. Thus, this new heat warning system is based upon actual human-health responses as opposed to arbitrary heat index thresholds.

Depending on the specific weather conditions present, the NWS Office in Phoenix has specific instructions for their forecasters on whether or not a warning should be issued, along with whether the warning should be an “excessive heat warning” (dangerous conditions are expected within 24 h), an “excessive heat watch” (usually issued up to 48 h before an oppressive air mass is forecast), or a “heat advisory” (less severe than an excessive heat warning). These different categories are used to inform city health officials of the severity of the heat wave and the potential human-health response.

The last important component of the heat warning system is intervention by the city and health department to help prevent any deterioration in human health. The city of Philadelphia has a particularly elaborate set of interven-

tion plans, and recent research has suggested that many lives have already been saved as a result (Ebi et al. 2004; Kalkstein et al. 1996b). For example, when an excessive heat warning is issued in Philadelphia, the following steps are taken: media announcements of the warning, a “buddy system” goes into effect where volunteers check on the elderly, a telephone hotline called the “Heatline” is activated, the Department of Public Health makes home visits to susceptible portions of the population, utility suspension is halted, medical service staff are increased, outreach for the homeless increases, and designated air-conditioned facilities are opened for the public (Kalkstein et al. 1996b). Unfortunately, Phoenix does not have an organized intervention plan with regard to excessive heat warnings, and only after many consecutive days of excessive heat warnings and heat advisories in the summer of 2005 did Phoenix officials begin to distribute water and open air-conditioned shelter areas. However, this only occurred after numerous deaths had been reported. In all, the summer of 2005 was particularly bad for Phoenix, and at least 18 people were killed as a direct result of a severe heat wave from 12 to 20 July (Villa 2005).

By examining the social response to the heat warning system in Phoenix, a wide range of information can be obtained which will serve to help improve heat warning systems not only in Phoenix, but in other places across the country. Thus, the goal of this research is to evaluate the social impacts of the heat warning system in the Phoenix Metropolitan Area. This study will focus primarily on the public’s perceived risk and response to heat and heat warnings, since perceived risk is often associated with increased action.

Materials and methods

The data were obtained by distributing questionnaires at various locations across the Phoenix Metropolitan Area (Appendix A). Phoenix, the capital of Arizona, is located in the Desert Southwest and provides an interesting location to conduct this study considering it is the hottest major city in the United States. Phoenix and its surrounding cities including Mesa, Scottsdale, Tempe, Gilbert, Chandler, and Peoria, are situated in the Salt River Valley, where summertime temperatures frequently exceed 105°F (40.5°C). The Phoenix Metropolitan Area is composed of only two counties, Maricopa and Pinal, although the vast majority of the population resides in Maricopa County, where all surveys were distributed.

The text of the surveys focused heavily on behavioral changes as a result of heat warnings. A total of 201 surveys were distributed at eight different locations across the research area from 21 through 24 December 2005. This

study was conducted as part of a graduate research and field examination for Arizona State University, thus making a summertime distribution of surveys impossible. Only one person handed out surveys, and each survey was filled out individually by the participant. As with all self-survey studies, this methodology has several limitations. For example, there is likely a small social desirability bias, in which respondents tend to write what they perceive to be the socially accepted answers, not necessarily presenting an accurate picture of the individual’s thoughts. Also, the survey does not poll a completely random sample; those who choose not to complete a survey are excluded. Finally, to save time, some respondents might check similar answers for each question rather than spending the necessary time to think about each one. Still, despite these drawbacks, survey distribution continues to be a common method used to gather information about a population, and a recent study by Sheridan (2006) conducted a phone survey across four cities to gain insight into the perception of heat among the elderly.

The specific survey locations were chosen to obtain data that best represent the diverse nature of the Phoenix Metropolitan Area and were often located in front of shopping centers where numerous people were present. Of the eight survey locations, two were located in the East Valley, two were located South of Phoenix, two in the North Valley, one in a northwest suburb (predominantly elderly) and two in downtown locations (predominately Hispanic). Totals of 30 surveys were distributed in each location with two exceptions; 12 surveys were distributed in one downtown location and 9 were distributed in one of the northern locations. It is important to note that the survey was only conducted on English-speaking participants, and as a result, the Spanish-speaking portion of the population is likely underrepresented in this study. However, the percentage of Hispanic respondents is representative of the local population. Surveys were only distributed to people who live in the Phoenix Metropolitan Area throughout the summer months, thus excluding those who spend only the winters in the city. Only one survey was distributed per household.

The participants in this study consisted of 73 males, 122 females, and 6 unidentified; the higher number of females is attributed to the fact that they were more likely to fill out surveys compared to males. In addition, many surveys were distributed during the early afternoon, when the majority of people running errands or shopping were female. Of the 201 surveys, 120 listed their racial or ethnic background as White, 42 Hispanic, 14 Black, 8 Native American, 4 Asian, 8 other, and 5 unidentified. The age of the respondents was slightly skewed towards the younger age groups, which was likely caused by several factors. First, many of the elderly only live in the

city during the winter months, thus excluding them from the study. Next, younger people were more likely to stop and fill out a survey compared to the elderly. Finally, according to the 2000 census, less than 11.9% of the population in the Phoenix Metropolitan Area is over 65. The breakdown among age groups is as follows: 55 of the respondents were 18–29, 43 were 30–41, 48 respondents were 42–53, 36 were 54–65, and 14 participants were over 65 with 5 unidentified. Finally, the annual income for the entire household, as reported by the respondents were: 31 participants made under \$20,000, 44 made from \$20,000 to \$40,000, 38 from \$40,000 to \$60,000, 28 from \$60,000 to \$80,000, 15 from \$80,000 to \$100,000, and 29 reporting over \$100,000 per year with 16 unidentified. Most of the unidentified were located in Scottsdale, a wealthy suburb of Phoenix, and it is possible those who are wealthy are less likely to disclose their income. These demographic data varied tremendously from one location to the next, but, as a whole, they represent a very accurate sample of the Phoenix Metropolitan Area, according to the 2000 Census, with the notable exception being the male to female ratio.

Results

Warning awareness

Of the 201-person sample, the vast majority of respondents reported that they were aware of days when the NWS in Phoenix issued either an excessive heat warning or a heat advisory. In fact, only 28 participants (13.9%) were unaware that warnings had been issued. However, several participants were steadfastly convinced that Phoenix did not have a heat warning system, with one respondent even stating, “Now why would Phoenix need any weather warning systems?”

Surprisingly, the level of heat warning system awareness varied significantly across different demographic categories (Table 1). For example, 90.2% of females were aware of the heat warning system while only 75.3% of males reported being aware of the system. Furthermore, age and income

seemed to play large roles as well. While only 67.3% of respondents between the ages of 18 and 29 reported being aware of the system, 92.9% of those over 65 had heard of it. Similarly, only one respondent making over \$100,000 had not heard of the system (3.4%), while 35.5% of those making under \$20,000 were not aware that warnings had been issued (Fig. 1). Finally, the differences among races were smaller, but Whites (90.5%) were slightly more likely to have heard of the heat warning system compared to Hispanics (81.0%).

Perceived risk

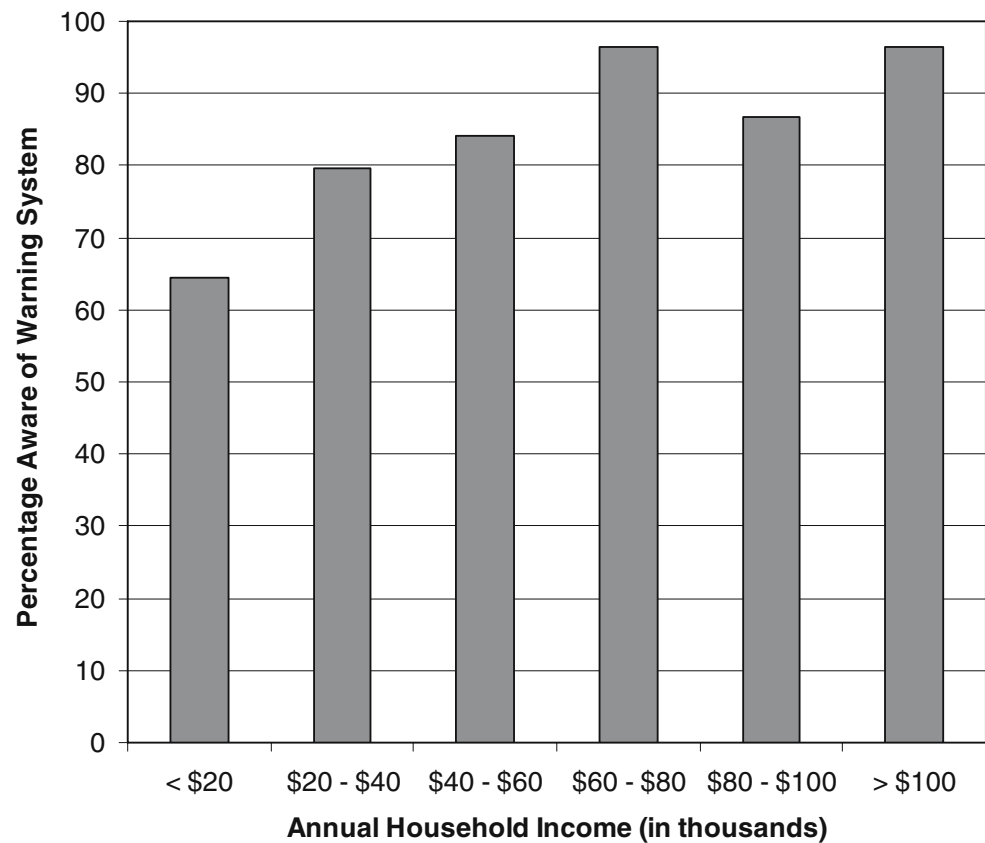
The perceived risk of heat among the participants was examined with the following question: “How dangerous do you think the heat is for you?” Over 25% of the respondents reported that the heat was “very dangerous” for them and 44.7% reported that the heat was “somewhat dangerous” for them. Only 7.6% felt that the heat was “not at all dangerous”. Not surprisingly, the responses varied somewhat among different demographic segments of the population. First, women were slightly more likely than men to report that the heat was very dangerous for them. Furthermore, while only 17.9% of White respondents felt that heat was very dangerous for them, 46.3% of Hispanics felt similarly, clearly indicating an elevated sense of perceived risk among Hispanics. Finally, 32.1% of youngest age group felt that heat was very dangerous for them, more than any other age category.

Another potential indicator of perceived risk was measured in the question: “Which natural disaster do you think is the biggest threat to you?” 50.6% of the participants believed that heat was the biggest threat to them, although this value is likely biased since many of the preceding questions pertained to the heat. Of the remaining disasters, 19.4% felt that thunderstorms and lightning were the biggest threat, while hurricanes, tornadoes, earthquakes, floods, and dust storms each had less than 10%. Once again, race seemed to play a major role. For example, 27.0% of Whites reported that thunderstorms/lightning were the biggest threat to them, while none of the 31 Hispanics reporting felt similarly. In addition, 64.5% of

Table 1 Percent respondents who were aware of the heat warning system

	Sex		Race				Age (years)				
	Male	Female	White	Hispanic	Black	Other	18–29	30–41	42–53	54–65	>65
Percent aware	75%	90%	88%	81%	79%	80%	67%	91%	96%	86%	93%
<i>n</i>	73	122	120	42	14	20	55	43	48	36	14

Fig. 1 Average annual income versus the percentage of respondents who were aware of the Phoenix heat warning system



Hispanics believed that heat was their biggest threat compared to only 49.0% of Whites.

To examine the “cry wolf” effect, an important factor in perceived risk, participants were asked whether they thought the NWS issued the proper number of warnings for all weather-related phenomenon. The majority (64.7%) believed that the NWS issued the proper number of warnings, 21.6% said the NWS issued too few warnings, and only 13.7% felt there were too many warnings. However, there were several interesting differences among the respondents. For example, Whites were more likely than Hispanics to believe that the NWS issued the proper number of warnings. Age also played a role: while less than 50% of those between 18 and 29 felt that the proper number of warnings was issued, 85.7% of those over 65 felt similarly. Furthermore, only 41.0% of those making under \$20,000 per year thought the NWS issued the correct number of warnings compared to 89.0% for those making over \$100,000. Surprisingly, this question seemed to have little impact on how seriously individuals took the warning. For example, only 6.7% of those who reported not taking the warning at all seriously felt that the NWS issued too many warnings. Most interesting, however, is that among those who were unaware heat warnings had ever been issued in Phoenix, half felt that the NWS issued too few warnings. Clearly, there are individuals within the metro-

politan area who are not getting any weather warning messages.

Warning response and social impacts

Much of the questionnaire was dedicated to the social impacts and warning response of the participants. Several examples are: “Did you do anything different on these days as a result of the warning or advisory?”, “Were you worried when you heard about the excessive heat warning or heat advisory?”, and “Overall, how much did your daily activities change as a result of the excessive heat warning or heat advisory?” Not surprisingly, answers to these questions varied considerably across the different demographic categories.

Of the 169 participants who reported that they were aware of the heat warnings and advisories, 84 (49.7%) said they did something different on those days while 80 (47.3%) respondents did not. Females were slightly more likely than males to change their behavior as a result of the warning; 53.7% of females reported doing things differently on days with warnings while 45.5% of males acted similarly. There were also differences reported between Hispanics and Whites: 61.8% of Hispanics reported changing their behavior on warning days compared to only 44.7% of Whites. Most surprising were the differences

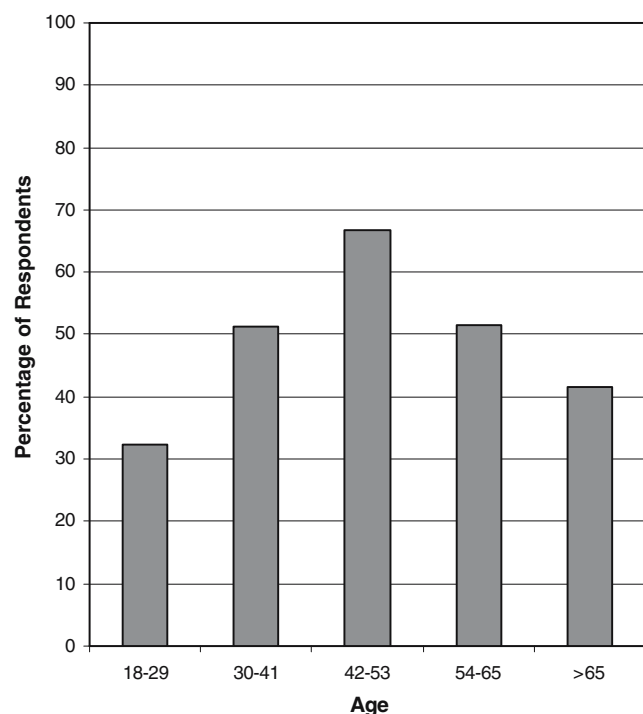
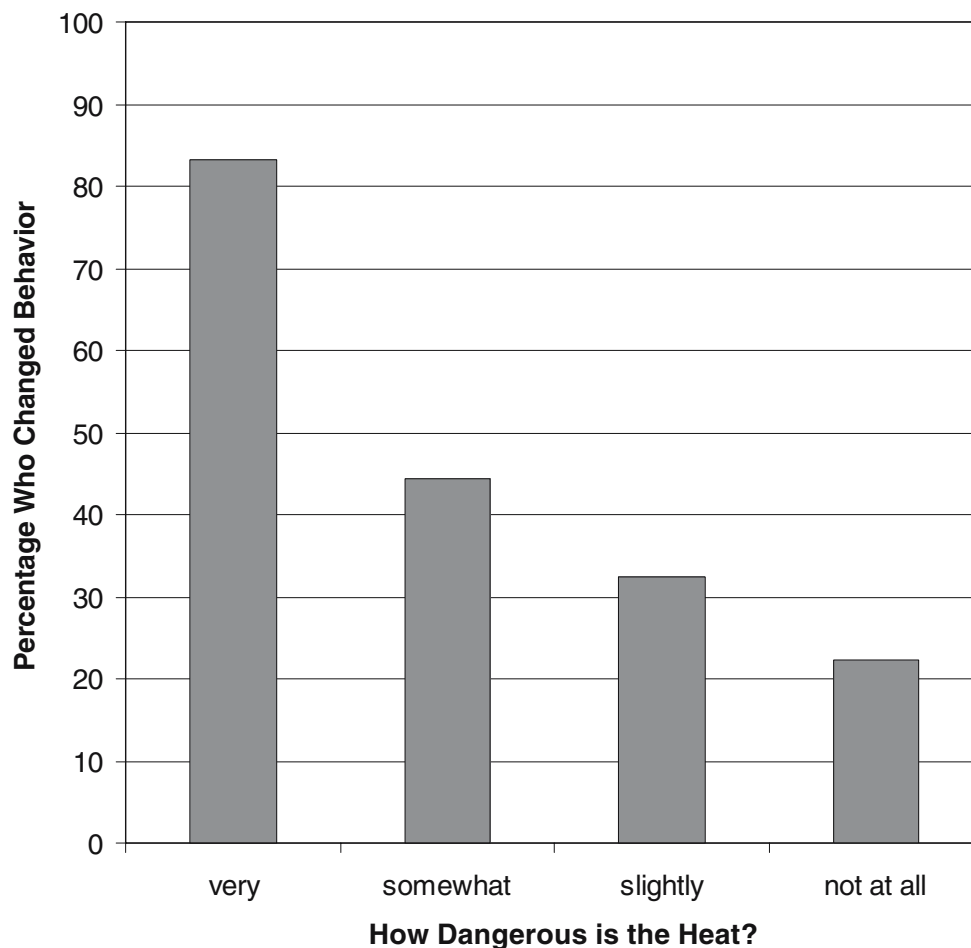


Fig. 2 Age versus the percentage of respondents who reported changing their behavior during days with heat warnings or advisories

Fig. 3 “How dangerous is the heat?” versus the percentage of respondents who changed their behavior on days with a heat warning or advisory

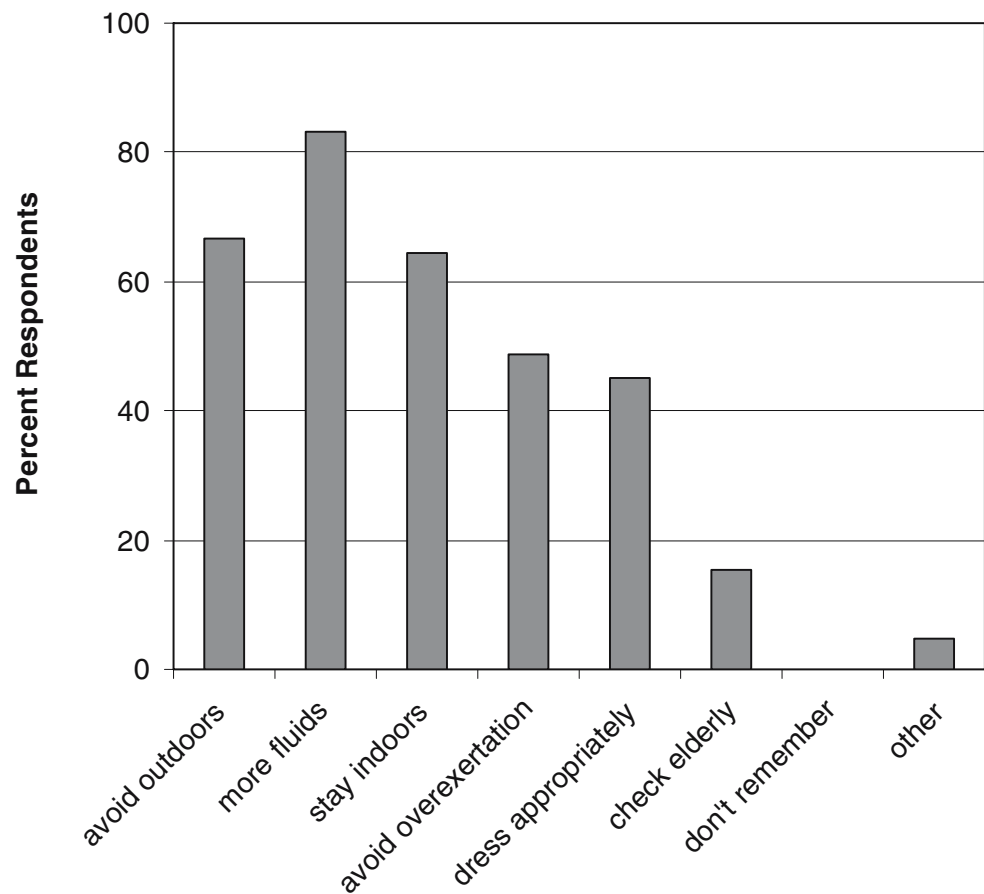


between age groups. For example, only 32.4% of those between 18 and 29 reported doing things differently on warning days compared to 66.7% between 42 and 53 (Fig. 2).

One question in the survey directly asked each participant how much their activities changed as a result of the warning or advisory. Of the participants, 29.4% reported not changing their behavior at all, while the remainder reported changing their activities a lot, some, or a little, although only 8.9% reported changing their activities a lot. Surprisingly, there were no notable differences for this question across demographic categories.

The strongest indicator of whether or not an individual altered their behavior on warning days was perceived risk. For example, Fig. 3 illustrates that the likelihood of whether or not a person changed behavior on warning days is highly dependent on how dangerous that individual perceived heat. While 83.3% of those who felt heat was very dangerous changed their activities on days with warnings or advisories, only 22.2% of those who felt heat was not at all dangerous changed. The results were similar for those who were worried about heat warnings. For example, 87.5% of those who were very

Fig. 4 Actions taken by respondents who reported they altered their behavior after hearing there was a heat warning or advisory issued



worried when a heat warning was issued changed their activities, and only 30.8% of those who were not at all worried changed.

Behavioral changes

There were 84 respondents who were aware that warnings had been issued and altered their behavior as a result. Of these 84 participants, the most common behavioral changes reported were drinking more fluids (83.3%), avoiding the outdoors/sun (66.7%), and staying indoors or seeking an air-conditioned location (64.3%) (Fig. 4). Although the responses of avoiding the outdoors/sun and staying indoors/seeking an air-conditioned location are similar, the latter suggests more initiative by the respondent in that they were actively seeking an air-conditioned location.

The 80 respondents that were aware of the warnings yet chose not to do anything different on those days provided reasons for their inaction in their survey, and not surprisingly, the most common response was: “It always seems hot in the summer.” Thirty-four people (42.5%) marked this as a reason why they chose not to act during an excessive heat warning or heat advisory. The next most common response was that they alter their behavior anyway during the

summer, independent of any warnings. Others noted that their work required them to be either indoors or outdoors, and a warning or advisory would not affect this. Finally, 14 participants (17.5%) listed that, “I wasn’t worried; there always seem to be weather warnings issued”, revealing the possible impacts of the cry wolf effect.

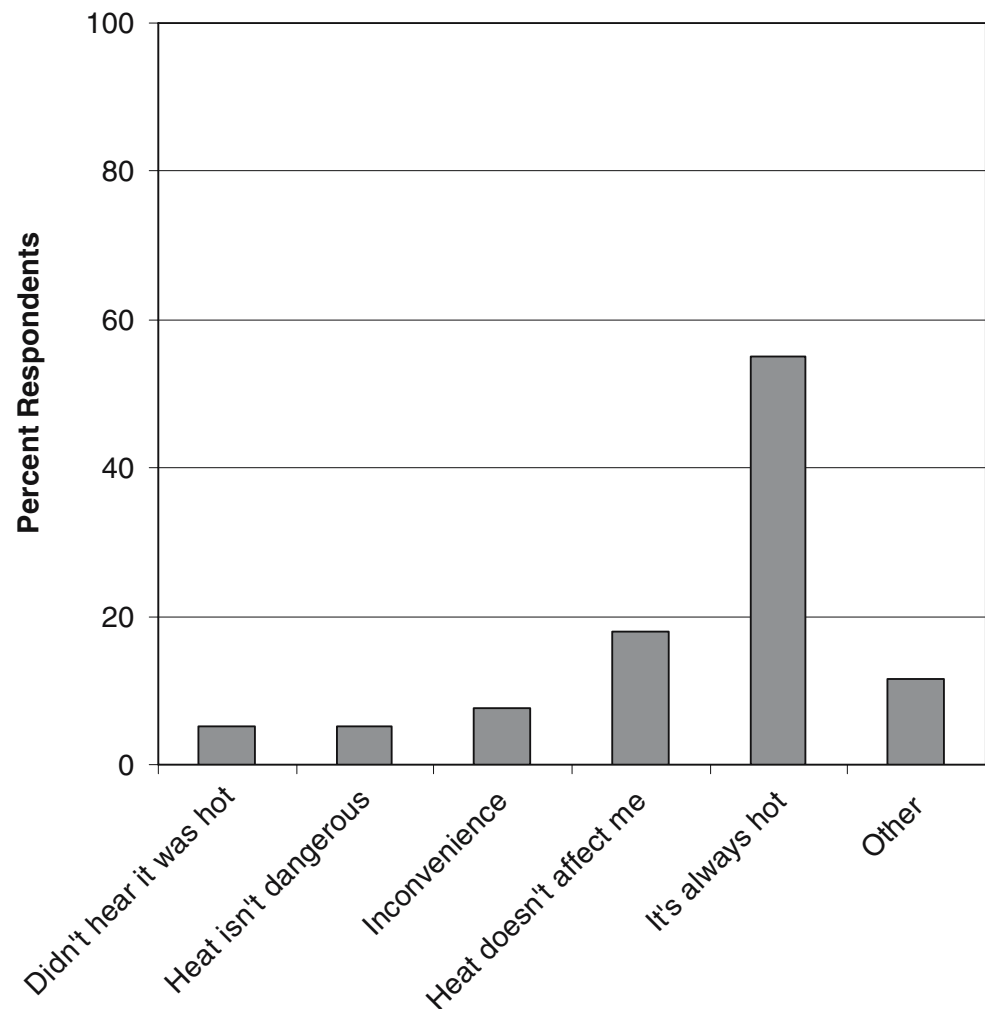
Overall, 117 respondents (60%) reported changing their behavior on excessively hot days, independent of any excessive heat warnings or heat advisories. Of these, 77.8% reported drinking more fluids, 72.6% avoided the outdoors/sun, and 71.8% went to an air conditioned location or stayed indoors. Of the remaining 78 participants who did not change their behavior on excessively hot days, 55.1% noted that it always seems hot in the summer, by far the most common response (Fig. 5).

Discussion

Awareness, perceived risk, and action

This study confirms that the majority of people living within the Phoenix Metropolitan Area are aware when excessive heat warnings or heat advisories are issued. Respondents over 65 years old reported the highest level of awareness with

Fig. 5 Reasons given as to why respondents didn't take action on excessively hot days



nearly 93% stating that they had heard of heat warnings in the past. This is especially important since that segment of the population is most at risk for heat-related illness. Thus, those who are most vulnerable to the heat are receiving the warning message. However, that does not necessarily mean that those over 65 are most likely to act during a warning. In fact, less than 50% of that age segment reported changing their activities as a result of the warning. This is worrisome and implies that although the message is going out, it is not always creating the desired response.

As expected, this study illustrates that perceived risk is highly correlated with mitigating action. This is in agreement with previous research suggesting that those who feel most at risk from a disaster are more likely to act when a warning is issued. Among those who choose to act when a warning is issued, there are notable social repercussions including an elevated sense of worry and noteworthy changes in daily activities.

One of the more surprising results and contrary to previous research, this study suggests that minorities have a

greater sense of perceived risk; Hispanics were far more likely than Whites to believe that heat is very dangerous to them. Furthermore, more Hispanics believed that heat is the biggest threat to them compared to Whites. Finally, Hispanics were far more likely than Whites to take an excessive heat warning “very seriously”. A possible explanation for these results is the prevalence of outdoor workers in Phoenix who are predominantly Hispanic. Even if an individual does not work outdoors himself, it is likely that the threat of heat is reinforced socially, through friends and family, leading to a community with increased heat awareness. The increased perceived risk among Hispanics translated into increased action, as 61.8% of Hispanics changed their behavior on days with warnings compared to only 44.7% of Whites. Thus, it is highly likely that social influences are responsible for increased perceived risk, and thus action, within the Hispanic community.

Another interesting finding is that age and annual income were good indicators of perceived trust of the NWS. The older age groups, along with those making

higher salaries, were more likely to feel that the NWS issues the proper number of warnings. This is important since previous research has illustrated that the cry wolf effect, the idea that too many warnings are issued, decreases perceived risk and, thus, mitigating action. Also, this study further confirms the cry wolf effect; only 36.4% of those who felt the NWS issued too many warnings changed their behavior on warning days. The fact that those with lower incomes were prone to the cry wolf effect could be a potential problem since that segment of the population might have less access to air conditioning. Furthermore, those with lower annual incomes are more likely to use evaporative coolers, which have been shown to become less effective during the North American monsoon season in the desert Southwest. The monsoon takes place in the late summer resulting in elevated dew points which reduce the efficiency of evaporative coolers, creating a potentially dangerous situation.

Social impacts

While it is evident that the majority of participants in this study alter their behavior throughout the summer, it is less clear what role the Phoenix heat warning system plays in these behavioral changes. Were the warnings the only thing responsible for participants drinking more fluids or avoiding the outdoors? For example, of the 84 respondents who were aware of warnings and reported altering their behavior as a result, how many would have changed their behavior anyway based solely on the weather forecast? How would their behavior differ if no warnings were issued? While the warnings surely had some influence, it is impossible to gauge the precise impact that the warning system had on behavior, and it is unlikely that the warnings were the only thing responsible for behavioral changes.

Similarly, another important aspect of this study is determining what constitutes a behavioral change as reported in the questionnaires. If someone changes their daily routine during June, July, and August, how would this be reported, and would the respondents consider this a behavioral change? There were 80 participants who reported hearing about the heat warnings, but not changing their behavior as a result. Despite their responses, there is no doubt that many of these 80 people exhibited some sort of behavioral change throughout the summer, including warning days. For example, 42.5% of those respondents reported that “it always seems hot in the summer” as the primary reason for not altering their behavior. It is possible that many of these responses could indicate that if it always seems hot in the summer, their behavior gets altered on a daily basis anyway. Other respondents reported that they change their behavior anyway on hot days, independent of

any advisories or warnings. These responses suggest that behavioral changes exist on a daily basis and that the vast majority of Phoenix residents do, in fact, change their behavior on particularly hot days, even if it is not a direct result of a heat warning or advisory.

It should be noted that while heat is an extremely deadly natural phenomenon, the mitigating action required to prevent heat-related mortality is often less memorable than that of other natural disasters. Thus, compared to other studies examining the social impacts of natural disaster warnings, this one likely underestimates the actual social response to the heat and, more specifically, to the Phoenix heat warning system. For example, a study on hurricane evacuations would yield more consistent results since evacuations are unusual, traumatic, and highly memorable. Here, it is possible that at least some of the respondents did not remember exactly what they were doing during a heat warning or advisory. Perhaps people took mitigating action as part of a daily routine or without realizing it and simply failed to note any change in behavior for this study. Heat is part of the daily summer life in Phoenix, and it is likely that some of the mitigating actions have become so routine, that many of the participants failed to mention them in the questionnaire.

Suggestions

This study illustrates that although the vast majority of people are receiving the message about heat warnings, only around half of the population report changing their actions on those days. Considering heat can be an extremely deadly weather-related phenomenon, the warning is not as effective as it needs to be. Many people who did not act during a heat warning responded that “it always seems hot in the summer.” Thus, the language in the warning issued by the NWS, along with the media outlets, need to make it exceptionally clear that days with excessive heat warnings are not “typical” summer days in Phoenix and can be extremely dangerous. Furthermore, since research has shown that people are more likely to act if they have clear instructions, residents should be urged in straightforward language to drink more fluids, seek air-conditioned locations, and participate in other mitigating actions during the warning days.

Equally important are the responses by the city of Phoenix and the Health Department during a warning or advisory. Phoenix should use Philadelphia as an example, setting up telephone hotlines, checking on the homeless and elderly, opening air-conditioned shelters, and distributing water. The summer of 2005 demonstrated what happens when relatively few steps are taken during a warning; only after many consecutive days of excessive heat warnings did officials begin to act, distributing water, and helping the

homeless. Unfortunately, these actions came too late, and 18 people lost their lives as a result.

The homeless are particularly prone to heat-related illness, and 14 of the 18 heat-related deaths reported during the July 2005 heat wave were homeless. This portion of the population has little access to television, radio, and the internet, which are the main outlets for the National Weather Service to broadcast heat warnings and advisories. Clearly, more needs to be done to alert the homeless when the weather is forecast to be dangerous and potentially life threatening. When warnings are issued, the city of Phoenix needs to act immediately to open air conditioned shelters that welcome the homeless.

While these findings are particularly relevant for NWS and health officials in Phoenix, this information can be used by other NWS offices across the United States to better gauge the effectiveness of their weather warning systems. In Phoenix, the majority of respondents were aware of the heat warning system, although those making under \$20,000 along with the younger age groups were less likely to have heard of the warnings. With these exceptions, the NWS and media outlets are doing a good job transmitting important information to most of the public. However, too few people are altering their behavior as a result of the warnings. This is a particularly dangerous situation, especially if individuals are also not responding to other weather warnings. Recent disasters such as Hurricane Katrina confirm these fears, as many people could not, or chose not to evacuate, despite the fact that warnings issued by the NWS stressed the potential danger of the situation. Considering many of the residents who remained in New Orleans during the hurricane were likely making under \$20,000, this study supports the fact that poorer segments of the population are simply not getting the message, possibly explaining why so many people did not evacuate. For those who do receive the proper warning messages, but do not alter their behavior as a result, NWS offices across the country need to emphasize increased education programs so that individuals will act when warnings are issued.

Appendix A

Survey Text

Adam Kalkstein, a PhD student from the Geography Department at Arizona State University, is conducting a project to help improve weather warning systems in Phoenix. All information you share is strictly anonymous; there will be no association between you and the information you give. Furthermore, I will never ask for your name, address, phone number, etc. This study has been approved by the ASU Institutional Review Board and shouldn't take more than five minutes to complete. Thanks for your participation!

1. Over the past several summers, were you ever aware of days when the National Weather Service in Phoenix issued an EXCESSIVE HEAT WARNING or a HEAT ADVISORY? (197 responses; 98.0%)

- ☐ YES
- ☐ NO If no, continue to question 8

1a. How did you hear about it? (select all that apply) (168 responses; 99.4%)

- ☐ Radio
- ☐ Television
- ☐ Newspaper
- ☐ Friend / Relative
- ☐ Social Services Person
- ☐ Other _____

1b. What recommendations were made to help people deal with the heat? (select all that apply) (168 responses; 99.4%)

- ☐ Avoid the outdoors / sun
- ☐ Drink more fluids
- ☐ Stay indoors / seek air-conditioned location
- ☐ Use a fan
- ☐ Avoid overexertion / take it easy
- ☐ Dress appropriately / wear light colors
- ☐ Check in on neighbors or the elderly
- ☐ I didn't listen / no suggestions were given
- ☐ Don't remember
- ☐ Other _____

2. Did you do anything different on these days as a result of the warning or advisory? (167 responses; 98.8%)

- ☐ YES if yes, continue to 2a
- ☐ NO if no, continue to 2b
- ☐ Don't remember

2a. What did you do? (select all that apply) (84 responses; 100%)

- ☐ Avoid the outdoors / sun
- ☐ Drink more fluids
- ☐ Stay indoors / seek air-conditioned location
- ☐ Avoid overexertion / take it easy
- ☐ Dress appropriately / wear light colors
- ☐ Check in on neighbors or the elderly
- ☐ Don't remember
- ☐ Other _____

2b. Why not? (select all that apply) (74 responses; 92.5%)

- ☐ Heat isn't that dangerous
- ☐ Too much of an inconvenience
- ☐ Heat doesn't affect me
- ☐ It always seems hot in the summer
- ☐ I wasn't worried; there always seem to be weather warnings issued
- ☐ Other _____

3. How seriously did you take the excessive heat warning or heat advisory? (168 responses; 99.4%)

- ☐ Very seriously
- ☐ Somewhat seriously
- ☐ Slightly seriously
- ☐ Not at all seriously

4. Were you worried when you heard about the excessive heat warning or heat advisory? (167 responses; 98.8%)

- ☐ Very worried
- ☐ Somewhat worried
- ☐ Slightly worried
- ☐ Not at all worried

5. Overall, how much did your daily activities change as a result of t excessive heat warning or heat advisory? (166 responses; 98.2%)

- ☐ My daily activities changed a lot
- ☐ My daily activities changed some
- ☐ My daily activities changed a little
- ☐ My daily activities didn't change at all

6. How would your behavior change on days with an excessive heat warni compared to days with a heat advisory? (163 responses; 96.4%)

- ☐ I would adjust my behavior on both days
- ☐ I wouldn't adjust my behavior for either day
- ☐ I would adjust my behavior ONLY for an excessive heat warning
- ☐ I would adjust my behavior ONLY for a heat advisory

7. If you drink alcohol, about how much did you drink on the days with an excessive heat warning or heat advisory (164 responses; 97.0%)

- ☐ I rarely/never drink
- ☐ I didn't drink on those days
- ☐ I drank on those days, but less than usual
- ☐ I drank the same amount as usual
- ☐ I drank more on those days
- ☐ Don't remember

8. In general, do you think the National Weather Service in Phoenix issues the proper number of watches or warnings for weather-related phenomenon? (190 responses; 94.5%)

- ☐ They issue too many watches or warnings
- ☐ They issue too few watches or warnings
- ☐ They issue the proper number of watches/warnings

What do you use to cool your house? (select all that apply) (200 responses; 99.5%)

- ☐ Central air conditioning
- ☐ Window air conditioning unit
- ☐ Evaporative cooler
- ☐ Nothing if nothing, continue to question 10

9a. Did you use your air conditioning or evaporative cooler on days with an excessive heat warning or heat advisory? (195 responses 97.0%)

- ☐ YES
- ☐ NO
- ☐ Don't remember
- ☐ N/A

9b. Were financial considerations part of your decision as to wheth or not to turn on the air conditioner or evaporative cooler tha day? (193 responses; 96.0%)

- ☐ YES
- ☐ NO
- ☐ Don't remember
- ☐ N/A

10. Do you generally do anything different on days you know are excessively hot? (195 responses; 97.0%)

- ☐ YES if yes, go to 10a.
- ☐ NO if no, go to 10b.

10a. What do you do differently? (check all that apply) (115 responses; 98.3%)

- ☐ Avoid the outdoors / sun
- ☐ Drink more fluids
- ☐ Stay indoors / seek air-conditioned location
- ☐ Avoid overexertion / take it easy
- ☐ Dress appropriately / wear light colors
- ☐ Check in on neighbors or the elderly
- ☐ Other _____

10b. Why not? (select all that apply) (72 responses; 92.32%)

- ☐ Didn't hear it was going to be hot
- ☐ Heat isn't that dangerous
- ☐ Too much of an inconvenience
- ☐ Heat doesn't affect me
- ☐ It always seems hot in summer
- ☐ Other _____

11. Which ONE of the following do you think is the biggest threat to you? (SELECT ONLY ONE) (160 responses; 79.6%; many participants selected more than one answer making their response invalid)

- ☐ Hurricanes
- ☐ Tornadoes
- ☐ Earthquakes
- ☐ Heat
- ☐ Floods
- ☐ Dust storms
- ☐ Thunderstorms / lightning

12. How dangerous do you think the heat is for you? (197 responses; 98.0%)

- ☐ Very dangerous
- ☐ Somewhat dangerous
- ☐ Slightly dangerous
- ☐ Not dangerous at all

13. How do you usually get your local news? (select all that apply) (197 responses; 98.0%)

- ☐ Newspaper
- ☐ Radio
- ☐ Internet
- ☐ Television
- ☐ Other _____
- ☐ I don't get local news

14. Are you male or female? (195 responses; 97.0%)

- ☐ Male
- ☐ Female

15. What is your racial or ethnic background? (196 responses; 97.5%)

- ☐ White
- ☐ Hispanic
- ☐ Black
- ☐ Native American
- ☐ Asian
- ☐ Other

16. What is your age? (196 responses; 97.5%)

- ☐ 18–29
- ☐ 30–41
- ☐ 42–53
- ☐ 54–65
- ☐ Over 65

17. What is your approximate annual income for your entire household? (11 responses; 92.0%)

- ☐ Under \$20,000
- ☐ \$20,000–\$40,000
- ☐ \$40,000–\$60,000
- ☐ \$60,000–\$80,000
- ☐ \$80,000–\$100,000
- ☐ Over \$100,000

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