

A survey of public perception and response to heat warnings across four North American cities: an evaluation of municipal effectiveness

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Abstract To examine the efficacy of municipal heat watch warning systems, a thorough evaluation of the heat mitigation plans of four North American cities - Dayton (Ohio, USA), Philadelphia (Pennsylvania, USA), Phoenix (Arizona, USA), and Toronto (Ontario, Canada) - was undertaken. In concert with this evaluation was a survey of residents in the metropolitan areas of these cities that gauged their perception of their own vulnerability to the heat, as well as their knowledge of heat warnings and the activities recommended to be undertaken to help mitigate the effects of the heat. In total, 908 respondents participated in the telephone survey. Some of the key results indicate that knowledge of the heat warning was nearly universal (90%), and likely due to pervasive media coverage more than any other means. Though knowledge of the event was widespread, knowledge of what to do was less common. Only around half of all respondents mentioned that they changed their behavior, and despite the diversity of information available on mitigating heat vulnerability, most respondents stated that they merely “avoided the outdoors” at all costs. Though air conditioning was nearly ubiquitous among respondents, over a third mentioned that economic factors of energy costs were considered in terms of how long or whether the air conditioner was turned on.

Keywords Heat watch-warning systems · Heat vulnerability · Hazards · Survey · Perception

Introduction

While not receiving as much attention as other weather-related disasters, oppressive summertime heat claims more lives than all other disasters combined (National Climate Data Center 2006). Especially since the heat wave of 1995, during which the US media highlighted the several hundred Chicagoans that lost their lives over several days (e.g., Klinenberg 2002; Palecki et al. 2001), there has been a significant increase in interest in heat vulnerability. This interest has led to the development of different, more locally targeted forecasting methodologies and/or mitigation strategies (Sheridan and Kalkstein 2004). Yet despite the interest in studying heat vulnerability, no published study has examined how individuals perceive their own vulnerability and their options for dealing with the heat. Thus, improved forecasting and mitigation strategies will be of little benefit if the local individual does not understand the warnings provided, perceive him- or herself as being vulnerable to the heat, or know how best to avoid harm’s way.

Thus, the goal of this article is to assess the efficacy of cities’ heat mitigation strategies in terms of providing awareness and evoking a response from their citizens. To achieve this goal, first, a review of the heat mitigation plans of four North American cities (Fig. 1) was undertaken: three cities with humid mid-latitude climates - Dayton (Ohio, USA), Philadelphia (Pennsylvania, USA), and Toronto (Ontario, Canada)- and one city with a low desert climate - Phoenix (Arizona, USA). Next, to assess the efficacy of these mitigation plans, an analysis of sample populations in each of these cities’ metropolitan areas were studied with regard to their perception of their own heat vulnerability, their knowledge of options for

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Fig. 1 The four cities incorporated into this research. The numbers in parentheses represent the sample sizes for the survey work



dealing with the oppressive weather, and why they did or did not take action to avoid a negative health outcome during the heat event.

Materials and methods

Research was conducted during the summers of 2004 and 2005. The individual heat events that were assessed across the four cities are listed in Table 1. Only a total of 2 days were incorporated from 2004, a below-average summer in terms of temperature across much of eastern North America. Summer 2005 was much warmer, and thus virtually all of the results, including over 95% of survey work, is derived from this year.

The mitigation analysis focused upon the communications relayed to the public, both in terms of the means of dispersal as well as the content. Communications were obtained from both the local health and local meteorological authority, where applicable, for all events listed in Table 1. All available information on heat illnesses or fatalities, as well as cooling center openings and calls to heat information hotlines, was also gathered.

As much research (e.g., Whitman et al. 1997) has shown that the elderly are disproportionately affected during heat events due to physiological and social reasons, the survey was developed for those solely of age 65 and older. The questions within the survey were developed in consultation with health officials in the cities of Toronto, Philadelphia,

and Dayton. Pre-survey testing and the actual surveys were conducted via telephone by the Kent State University Survey Research Lab. Pre-survey testing included mock calls to local volunteers to assure that the questions were clear. Once this was completed, the actual survey calls were placed to residents within the metropolitan area of each of the cities of interest. Phone numbers were selected at random from a purchased database that contained home telephone numbers representing households headed by someone 65 years of age or older. As Canadian law forbids such subdivisions, phone numbers in Toronto were selected from a database of all phone numbers. All survey work was done within 7 days of the end of a heat event.

A total of 908 survey respondents were interviewed across the four cities of interest, with a successful interview rate of 5.4% of all phone calls (16,739). The success rate (Table 2) was approximately 10% in Dayton, Philadelphia, and Phoenix; in Toronto, a lower success rate of approximately 2% was attained due to the inability to stratify Canadian phone numbers. Unsuccessful calls included calls to non-working telephone numbers, respondents outside of the target population, and hang-ups.

Mitigation plans

Across the four cities examined in this research, a diverse array of heat mitigation activity occurs. One city, Phoenix, has no official heat mitigation plan. Among the other three,

Table 1 Hot days surveyed in this research. Listed with each event is the number of respondents surveyed (*n*), the type of heat event declared (explained in text) along with meteorological conditions. Tmax refers to the mean maximum temperature (°C) during event; Tmin refers to the mean minimum temperature, and Td refers to the mean dew point temperature

Dates	<i>n</i>	Event	Tmax	Tmin	Td
Dayton					
24–26 July 2005	161	3 warnings	34	24	22
Philadelphia					
14 June 2005	100	Advisory	34	25	21
18–19 July 2005	40	2 warnings	33	24	23
25–26 July 2005	105	3 warnings	35	22	22
3–5 August 2005	100	3 warnings	36	25	19
12–14 August 2005	55	3 warnings	36	25	23
Phoenix					
11–13, 16–19 July 2005	163	4 advisories, 3 warnings	45	31	7
Toronto					
8–9 June 2004	40	2 alerts	32	18	20
6–7, 9–14 June 2005	49	3 alerts, 5 extreme alerts	31	21	19
25, 27–30 June 2005	32	2 alerts, 3 extreme alerts	33	21	18
10–18 July 2005	16	1 alert, 8 extreme alerts	33	22	19
2–4 August 2005	47	1 alert, 2 extreme alerts	32	21	20

Dayton, a smaller city, has a less extensive mitigation plan than the two larger cities of Philadelphia and Toronto, both with more resources at their disposal.

Dayton

The Combined Health District of Montgomery County is the primary agency in charge of the mitigation plan for the city of Dayton and the surrounding county. The heat mitigation plans were developed in 2000 using the synoptic-based Southwest Ohio Heat Watch/Warning System (SOHWWS), as described in Sheridan and Kalkstein (2004). The system contains a two-tiered intensity scale: the lower-level “heat alert” (associated with a predicted excess mortality of one or two deaths) and the higher-level “heat emergency” (three deaths or higher).

When a *heat alert* is declared by the city health commissioner after consultation with SOHWWS as well as National Weather Service (NWS) forecasters in Wilmington, Ohio, more than 150 “Heat Mitigation Partners” are notified (Combined Health District of Montgomery County 2001), including the Health Department’s media staff, city governments, police and fire departments, the local Red Cross, television stations, coroners’ offices, as well as recreation- and elderly-based agencies. Contact is

Table 2 Responses to several survey questions, stratified by city

	Dayton	Philadelphia	Phoenix	Toronto
A. Aware that there was a warning	92%	91%	90%	83%
B. Behaved any differently because of the warning	57%	47%	35%	46%
C. Drank more water than normal during the heat event	51%	51%	43%	58%
D. Drank less alcohol (of those that drink at all)	6%	32%	20%	19%
E. Have ever sought out a cooler location on a hot day	8%	15%	14%	17%
F. Behave any differently on days they know are hot	66%	52%	53%	57%
G. For whom cost was a factor in air-conditioning usage	35%	36%	30%	47%

by a fax or by e-mail on the morning of the event, and includes an announcement of the event along with suggestions for reducing heat vulnerability, including clothing guidelines, proper diet, methods for keeping the house cool, not leaving children or animals in vehicles, and the identification of vulnerable persons. In addition, the warning that a fan can be deadly when utilized in a closed environment in which the ambient temperature exceeds 35°C is included.

Each agency has an “Agency Action Sheet” in which mitigation plans are outlined. A survey conducted by the Health District in 2002 found that over 95% of partners received prompt notification of events and were satisfied with their plan, while over 90% successfully implemented those tasks listed on their action sheet (Combined Health District of Montgomery County 2003).

The declaration of a *heat emergency* prompts additional activity beyond what is done for a heat alert. Faxes contain information in somewhat greater detail than the heat alert fax, and stress that the term “heat emergency” is utilized. Utilities are discouraged from disconnecting services and the city of Dayton implements the “buddy system” (in which local citizens are enlisted to check up on elderly neighbors) throughout the city. “HelpLink”, a hotline for heat-related health questions, is also implemented during heat emergency days.

In addition, the NWS office itself also issues heat-related messages. As with all US cities, the official NWS suite of projects includes the higher-level “Excessive Heat Warning”, and the lower-level “Heat Advisory”, both of

which signal offensive weather within 24 h. There is also a “Heat Watch” program, which signifies that the heat may become oppressive within 24–48 h. Though there are no official mitigation plans associated with the NWS advisories, watches, and warnings, these are readily available to media outlets, and are issued up to 48 h in advance of the heat event. In the surveyed example (24–26 July 2005), the initial excessive heat watch was issued at 4:00 am on 23 July, the day before the excessive heat began. It should be noted that, despite the National Weather Service issuing an Excessive Heat Warning, the lower-level heat advisory was called by the Combined Health District of Montgomery County for the event surveyed in this research (Maier 2006, personal communication). One direct heat-related fatality was associated with the surveyed event in Dayton.

Philadelphia

Of the cities examined in this research, Philadelphia has the longest-running and most far-reaching heat watch/warning system (HWWS). System interest began in 1991, and developed significantly after 114 persons died from the heat in the city in 1993 (Kalkstein 2002). Philadelphia became the flagship location for the new synoptic HWWS in 1995, with an update in 2003 to improve its real-time web functionality, as well as extend forecasts out to 5 days.

The National Weather Service in Mt. Holly, New Jersey issues the same suite of products as those described for Dayton above. Unlike Dayton, however, the Philadelphia Health Department does not act upon a lower-level heat advisory (when one to three excess deaths are forecast); only during an excessive heat warning (four or more excess deaths) are any heat mitigation plans implemented.

In preparation, the Philadelphia Health Department’s Division of Health Promotion has coordinated a significant education campaign prior to the “heat season”, including the sending out of hot weather information and advice directly to local civic agencies, clergy, and block captains within their “buddy system”. Over 6,000 groups and individual volunteers, identified prior to the summer, are contacted and provided information regarding the warning signs of heat stress and level of severity, identifying the most vulnerable persons, and treatment recommendations according to level of severity. Additional information leaflets are provided to these groups and individuals on such issues as the proper usage of a fan in hot weather, and stickers with the same information are also provided to place on the fans themselves, as well as water bottles (Robinson 2006, pers. comm.). Private agencies such as the Philadelphia Corporation for Aging have also been recruited to promote heat awareness ahead of an event occurring, via staff training and information presented at

senior centers as well as informational newsletters (Kalkstein 2002).

During a heat warning, a number of mitigation events are put in motion. First, all media are contacted and informed of the health commissioner’s decision to call a heat warning, and are provided with information on how to avoid adverse health effects. The press release contains different quotes each time to promote media use. Health Department staff is made available for media interviews. “Heatline”, a hotline operated by the Philadelphia Corporation for the Aging, is activated; the telephone number is publicized by all media, and the hotline makes available nurses for those significantly affected, and can pay home visits in extreme situations. Based on a previous sample, approximately 25% of calls were referred to nurses, and 3% of calls resulted in home intervention (Kalkstein 2002).

Additionally, nursing homes are directly notified, utility services are not disconnected, emergency medical service staff is increased, senior centers are opened longer, and air-conditioned shelters are available for those whom the Department of Public Health feels it necessary to move. During 2005, preliminary estimates suggest that at least 22 people died from the heat (Szatkowski 2006, pers. comm.).

Phoenix

As with the other cities examined in this study, the determination of whether to call attention to the heat begins with local meteorologists. The National Weather Service office in Phoenix also utilizes a synoptic-based HWWS. However, due to Phoenix’s unique climate among the cities for which heat systems have been developed, modifications are necessary, and have been developed by Sheridan and Kalkstein in conjunction with NWS forecasters. As a result, while the terminology of the NWS messages is similar to those of other US locations in terms of the warning/advisory/watch hierarchy, the forecast decision is based not only upon the occurrence of offensive air masses, but also the forecast maximum temperature and the time of year.

There is at present no official municipal heat-mitigation plan that incorporates the output of the HWWS. The Arizona Department of Health Services recognizes this need (Herrington 2005, pers. comm.), and has begun public awareness campaigns that include the hazards of internal car temperatures among other concerns. They have also assessed resources that are available to social service agencies, and while some social agencies increase activities on the hottest of days, there is no official structure or guidance activities.

One unique feature within Phoenix’s response to heat is the active engagement of the local National Weather Service office. More than any other office that utilizes the new synoptic-based HWWS, they have utilized the system

to its fullest, and have suggested modifications (as mentioned above), and have released messages more detailed than those of other NWS offices. However, it should be noted that there is no official dispersal of this information, but rather, it is left up to local media to determine what information to provide.

According to the Arizona Department of Health Services, during the heat event of July 2005 that was surveyed in this research, at least 19 people reportedly died of heat exposure (Herrington 2005, pers. comm.).

Toronto

The city of Toronto, similar to Philadelphia, maintains a very active heat mitigation program. Since it is a Canadian city, the nomenclature is different from the other three cities examined in this research, with a higher-level *extreme heat alert* and a lower-level *heat alert*. The determination of what to call begins with Environment Canada forecasters, who utilize a synoptic-based HWWS, developed in 2001 and similar to those described previously, except that the thresholds are based on percentage likelihood of excess mortality. An extreme heat alert is associated with a 90% likelihood of excess mortality, based on previous heat-health relationships, whereas a heat alert is associated with a 65% likelihood (Sheridan and Kalkstein 2004). Toronto Public Health, in consultation with forecasters and the HWWS, is responsible for the ultimate determination on whether to call a heat event.

Prior to the summer, the city issues information on the risks of heat to approximately 1,000 community partners and city agencies (Vittiglio 2005, pers. comm.). This information (found at <http://www.toronto.ca/health/beaheat.htm>) covers the subsets of the population most at risk, “how to keep cool”, warning signs of heat-related illness, as well as how to treat victims. Another leaflet, “Fan Facts”, provides the recommendations for utilizing a fan properly, including using it in or near an open window. Training for community agency staff and volunteers is provided on heat-related illnesses and treatment.

A press release fax (sent to all community partners) advertises the heat event. Timely notification is crucial, as key participants include Toronto Community and Neighbourhood Services, Toronto Emergency Medical Services (EMS), Toronto Parks and Recreation, the Police Service, and Canadian Red Cross. Notification is issued on the morning of the event, although when forecast in advance, a release announcing that a heat event is “expected” is sent. The heat alert triggers several main responses, including:

- The setup of “Heatline”, to provide information similar to that described above. When necessary, nurses are available to offer advice and recommend locations for

finding cooler locales; in extreme circumstances, ambulances may be sent;

- bottled water is made available via “street patrols”; and
- agencies that maintain client lists that may be vulnerable make contact with those persons.

During an extreme heat alert, the above steps are taken, along with the opening of “cooling centers” throughout the city. At least one of these is open 24 h, and locations of cooling centers are included in all press releases (Day 2002).

During the hot summer of 2005, Toronto Public Health recorded over 12,000 visitors to the cooling centers during all of the heat emergencies. Further, 450 calls were placed to Heatline. From an initial total of 114 during the first heat event in June 2005, a total of 23 callers had home visits to check up on their status (Vittiglio 2005, pers. comm.).

Survey results

Demographic information

The demographic profile of the 908 respondents varies little across the four cities in terms of age and sex. The median age of respondents was either 73 or 74 in each city, with an absolute range of 65 to 97. Seventy-one percent of the respondents were female, statistically similar to that of the overall elderly population. Racially, the respondents include a greater percentage of whites than that of the overall population, with percentages ranging from 79% in Philadelphia to 95% in Phoenix; however, in comparison with Census 2000 (2001 in Canada) estimates of the racial profile of the elderly in each of the metropolitan areas, the racial distribution is fairly similar (US Census Bureau 2005; Statistics Canada 2005). The only statistically significant difference observed was an undersampling of Asians in Toronto (5% survey vs. 15% census; $p=0.0005$). Hispanics were also likely undersampled in Phoenix (1 vs. 7%), though direct statistical comparisons cannot be made as the survey question does not include Hispanic origin as an option separate from race as the US Census Bureau does.

In terms of living situation, results were statistically similar across all four cities. Fifty-nine percent of respondents live with at least one other person; 36% live alone but maintain regular daily contact with at least one other person; and 5% live alone with no such regular contact. The residences in which the respondents live vary widely by city (Fig. 2). The overwhelming majority of Dayton (80%) and Phoenix (75%) respondents reside in single, detached houses, whereas nearly half of Toronto (43%) and Philadelphia (48%) respondents live in an apartment

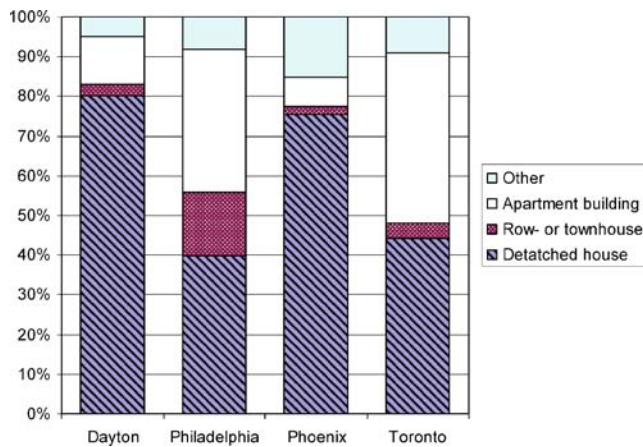


Fig. 2 Residence type of survey respondents

building. Row houses were only significant in Philadelphia (22%), and mobile homes comprised 7% of Phoenix respondents' dwellings.

Other information by respondents also corresponded well across cities. Approximately six out of ten respondents reported that they were "very healthy". Results were statistically significantly different across all cities ($p=0.017$), with the samples from Toronto and Phoenix considering themselves marginally healthier than those of Philadelphia and Dayton (64 vs. 55%). Only 5% of respondents reported that they had many health problems that make it difficult for them to accomplish their daily tasks. As these persons summed only to 45 respondents, it

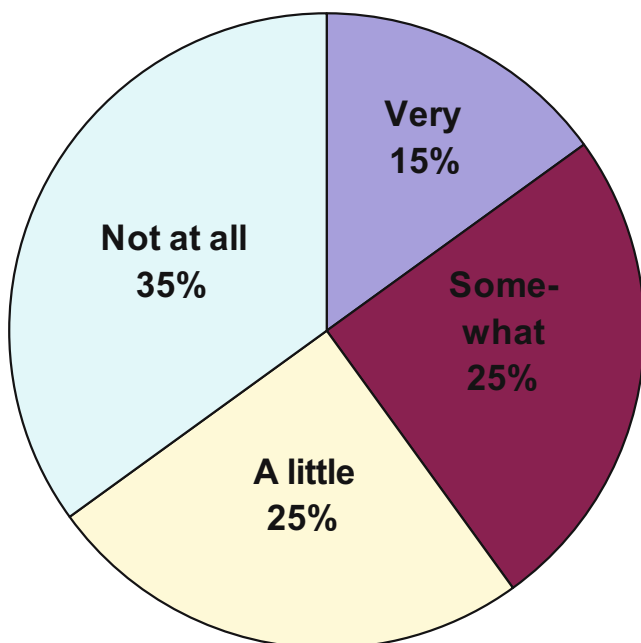


Fig. 3 Responses to the question, "How dangerous is the heat to you personally?", across all four cities combined

was not possible to adequately analyze their responses statistically, although their responses in terms of subsequent questions did not appear to be different from those of the sample as a whole. A large majority of respondents take medicine regularly, with marginally significant differences across cities ($p=0.047$) ranging from 78 in Toronto to 89% in Dayton.

Despite their age, more than half of all respondents believe that the heat either is not dangerous to them or only slightly dangerous to them (Fig. 3); only around one in seven respondents feel the heat is very dangerous. Responses varied little across the four cities studied.

Awareness

Several questions within the survey evaluated the relative efficacy of the heat warning systems in place, by asking respondents about their awareness of the warning¹ and its contents. Results show that, overall, nearly 90% of those surveyed stated that they knew about the warning; awareness was high in all cities, with a modest, but statistically significant ($p=0.017$) difference in Toronto, where only 83% of those surveyed were aware (Table 2, "A"). Though Toronto experienced more warnings than the other three cities, the notion that "warning fatigue" may explain this discrepancy does not appear to be valid, as across the five events surveyed in Toronto, there is no decline in awareness as the summer progresses. Another item of interest is comparing the first Philadelphia event in June 2005, during which only a "heat advisory" was called by the NWS, and all later events, which included "excessive heat warnings" (Table 1). Though the Philadelphia Health Department conducts no formal mitigation activities during heat advisories, 89% of respondents still stated that they knew of the advisory, compared to 92% of respondents knowing of the excessive heat warnings later in the summer.

Of those surveyed, many had advance knowledge at least 1 day before - a mean of 41% across the four cities, although this number is likely higher given the large proportion of respondents that could not recall or whose answers were not interpretable (Table 3). There is a significant difference ($p<0.001$) across the four cities, ranging from 50% in Dayton to only 29% in Toronto. Few of the respondents reported learning of the event afterwards, although several respondents, most notably in Phoenix, reported hearing heat warnings or at least "about the heat" so consistently that the recollection of the heat

¹ Note that, except where indicated, the phrase "warning" is used to encompass "excessive heat warning", "heat advisory", "extreme heat alert", and "heat alert".

Table 3 Responses to several survey questions regarding the respondents’ learning about the warning, stratified by city

	Dayton	Philadelphia	Phoenix	Toronto
How those that knew of the warning learned about it				
Television	89%	84%	92%	64%
Radio	10%	25%	22%	40%
Newspaper	22%	10%	38%	9%
Friend/Relative	2%	2%	17%	3%
Other	4%	5%	8%	8%
When those that knew of the warning learned about it				
At least the night before event	50%	43%	34%	29%
Day of event	22%	32%	23%	35%
After event	2%	1%	1%	1%
Hear warnings repeatedly	1%	4%	9%	2%
Don’t recall or miscellaneous	24%	21%	33%	33%

warning was more abstract. The means by which the respondents heard of the heat warning varied by city ($p < 0.001$) as well; via the television was by far the most common, although the radio was an important means in Toronto, as was the newspaper in Dayton and Phoenix. Hearing from a friend, neighbor, or relative was only significant in Phoenix. Approximately 4% of respondents intimated that they “perceived the warning on their own”, presumably by experiencing the heat.

Comparing these results to the results when respondents were asked as to how they “normally” receive their news, results are relatively similar, though there are notable

exceptions. Television is most the common method as well, claimed by 83% of all respondents. Only in Toronto did a statistically significantly lower percentage ($p = 0.004$) hear about the warning on television (64%) than those that typically get their news that way (77%). In comparison, radio was more common in Toronto than the normal means (51 to 40%); in all other cities percentages were similar. Far more ($p < 0.001$) of the elderly respondents get their news usually via newspaper (51%) than heard about the warning this way (17%), likely due to the time delay in newspaper information. The Internet remains relatively unused by these respondents, with only 3% reporting that they normally find news that way, and a similarly low percentage that heard about the warning via that means.

An open-ended question inquired about the respondents’ recollections of the specific recommended actions associated with the warning. Responses varied considerably (Table 4), and the most common themes across the cities were threefold: avoiding the outdoors and/or direct sunlight; keeping oneself hydrated; and being in an air-conditioned location, coincident with the main focus of mitigation messages, as discussed above. Results varied from city to city, with a predominance of avoiding the sun and drinking water at Dayton and Phoenix, and a more diverse set of responses in Toronto and Philadelphia. Philadelphians were especially responsive in terms of seeking out an air-conditioned location along with the correct utilization of fans. More than 30 respondents directly mentioned not utilizing fans with the windows closed, e.g.:

Stay indoors; wear light clothes, drink lots of water, make sure your windows are open if you don’t have a/c.

Table 4 Responses to several survey questions regarding the respondents’ recollections of advice and actions taken, stratified by city

	Dayton	Philadelphia	Phoenix	Toronto
Recommendations recalled				
Avoid the outdoors / sun	76%	59%	79%	62%
Keep hydrated	63%	44%	49%	38%
Stay in or seek an air-conditioned location	35%	52%	20%	36%
Utilize fans	11%	28%	1%	0%
Avoid overexertion	10%	7%	14%	19%
Dress appropriately	9%	9%	4%	3%
Check on neighbors or the elderly	2%	6%	1%	1%
Messages targeted elderly, children, sick	6%	7%	5%	15%
Cooling centers / Hotline / Other Muni activity	4%	9%	1%	12%
Didn’t listen/ no suggestions	9%	9%	12%	12%
Actions taken				
Stayed in the house (especially midday)	47%	32%	25%	31%
Limited or changed activity	9%	12%	11%	17%
Kept hydrated	5%	5%	1%	3%
Sought out a cooler location	0%	2%	1%	3%
Other	2%	3%	3%	3%

A minority of respondents felt that the messages were targeting only those that were ill or elderly, e.g.:

A whole list that was geared to seniors and ill people - don't go out unless necessary... (Philadelphia)

People should stay in the house and the elderly should go to special locations. (Dayton)

Though there is a large variability within the elderly population, it is interesting to note that many of these respondents, despite being over 65, did not believe they personally were in a vulnerable category.

In Phoenix and Toronto, the heat events coincided with high ozone days as well; several respondents clearly expressed confusion between how to protect oneself from the heat and how to reduce pollution levels:

Elderly stay inside and younger ones drive less if you can... (Toronto)

Last, though the numbers were generally low, several respondents, most notably in Philadelphia (9%) and Toronto (12%), cited municipal programs for those without proper means to cool themselves. In Philadelphia, the availability of free fans was most common, whereas in Toronto the availability of municipal cooling centers was mentioned most. A few respondents did cite concerns about reaching these cooling centers, e.g.:

... the cooling stations are too far for those who do not have cars... (Toronto)

Behavior

Though approximately nine out of ten respondents knew of the heat warning, many fewer actually modified their behavior on such days (46%). This percentage varied significantly ($p=0.003$) across the four cities of the study (Table 2, “B”), ranging from a low of 35% in Phoenix, where adjusting to hot weather would be more of a fundamental way of life, to a high of 57% in Dayton. The most common means cited by respondents was simply to stay indoors (Table 4), especially during the warmest parts of the day (33% of all respondents, and 72% of those that modified their behavior). A reduction or a restructuring of activities was next most common (12% and 26%, respectively). This response was strongest in Toronto, where respondents’ answers tended to suggest more “active” lives to begin with. Less than 2% sought out a cooler location; the actual location was typically an indoor shopping area although it also included heading into the mountains from Phoenix. Two Philadelphia respondents noted that they

went to the malls and the a/c at the malls was broken.

Few (4%) explicitly mentioned keeping hydrated, although in a subsequent question, when asked directly, about half of all respondents (51%) claimed to have drunk more water than normal. There was a marginally statistically significant difference ($p=0.046$) across the four cities, with Phoenix, where water consumption arguably would typically be higher on average, lower than the other three cities (Table 2, “C”).

More than three-fourths of all respondents reported that they do not consume alcohol; however, among the subset that do, only 22% reported drinking less on that day (Table 2, “D”). Significant differences occur across the cities ($p<0.0001$), with only 6% of Dayton respondents replying that they drank less alcohol. A total of 6 respondents (3% of those that drink) consumed more than normal during the heat event.

In later questions in the survey, behavior was evaluated on all hot days, not just those of the recent heat event. Overall, only approximately 13% of all respondents have ever sought out a cooler location on a hot day (Table 2, “E”). Only 12% of Torontonians went to the lakeshore at some point to escape the heat. Of those that did not seek a cooler location, the majority (72%) could name a cooler place to go were the need arose; shopping locations were most common (62%), followed by civic buildings (40%) and friends’ or relatives’ houses (10%). Differences were not statistically significant across cities. Nevertheless, few (only 10% of all respondents; again statistically similar across the four cities) had even contemplated going to a cooler location.

Respondents were also later asked whether they would do anything different on days when *it was hot*, instead of *because of the heat warning*. Interestingly, in all cities, the response was greater for hot days than for warning days; this difference was statistically significant ($p<0.05$) at Phoenix and Toronto, and near significance ($p<0.10$) at the other two cities (Table 2, “F” vs. “B”).

For those that responded that they did not change their behavior, several reasons were provided. For some, it was a misinterpretation of the question, as the respondent did the same as usual, they just did it at different times of the day, or indoors, e.g.:

I just stay inside and don't do any work outside.
(Dayton)

Other respondents, especially those in Phoenix, noted that with air conditioning being everywhere, there is no need to change any routine since it is always available. Other respondents cited that they are not susceptible to the heat, e.g.:

I'm a tough old broad - I still go outside and do work outside until I get hot - I don't stay in all day.

(Philadelphia)

I'm a bad girl - I delivered papers today and I probably shouldn't have (Philadelphia)

I am a phenomenal athlete. I just wear light clothing. (Toronto)

Last, a minority of respondents commented that they did little to make themselves susceptible on any day, e.g.:

Because I usually don't do that much outside my apartment anyways. (Dayton)

Cooling systems within the house

Nine out of ten respondents reported that they own an air conditioner, whereas eight out of ten reported owning a fan. Once again, significant differences ($p=0.001$) were observed; not surprisingly, an air conditioner and fan were most common in Phoenix (98 and 88%, respectively), closely followed by Dayton (95 and 85%) and Philadelphia (95 and 81%). Torontonians were least likely to own either equipment (84 and 72%). The types of air conditioners and fans varied significantly across the city; central units are far more common in the newer housing of Phoenix (82%) than the older stock of Philadelphia (56%). It is interesting to note that in Dayton, 77% of respondents reported owning central air conditioning, despite the housing stock being more similar in age to Philadelphia's (45% vs. 50% built before 1959) than Phoenix's (11%) (US Census Bureau 2005). It is likely that in Dayton's case, the larger proportion of single houses are more accommodating to central air-conditioning than Philadelphia's multiple-unit houses.

Though the differences are statistically significantly different across the cities for both air conditioning ($p=0.001$) and fans ($p=0.041$), 93 and 75%, respectively, of those that owned the devices utilized them during the heat events. As a subset of all respondents (inclusive of those that do not own an air conditioner, between 91 and 93% of respondents in the three US cities had an air conditioner operational (Fig. 4), with a much lower rate of only 69% in Toronto. Fan usage ranged from 67 to 72% across Phoenix, Dayton, and Toronto, with a lower rate of 58% in Philadelphia.

More than one-third of those with air conditioning reported that economic conditions were a factor in determining home air conditioner usage (Table 2, "G"). This number was statistically significantly ($p=0.033$) higher in Toronto than the other three cities, with nearly half of respondents reporting such consideration. A number of respondents within the open-ended questions to be discussed further below reiterated this concern about econom-

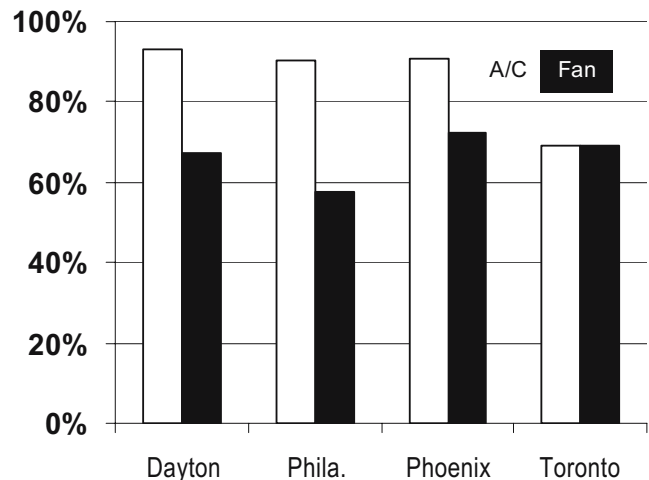


Fig. 4 The percentage of all respondents that utilized air-conditioning (white bar) and a fan (black bar) during the heat event

ics. Though clearly the majority of those with concerns utilized the air conditioner anyway, several intimated that it was not used as much as desired, potentially increasing one's vulnerability.

Of another concern are those that utilized a fan. The vast majority, nearly 75%, closed their windows while the fan was on, although it is clear that many of these also had an air conditioner running, for which this represents no problem. On the other hand, for those without air conditioning, a fan re-circulating air within the same hot room can rapidly enhance dehydration, and inhibit radiative and conductive heat loss (Toronto Public Health 2002, Centers for Disease Control and Prevention 2006). As education on this issue is particularly a cornerstone in Philadelphia's mitigation plans (as noted above), the smallest percentage of those who utilized fans with windows closed is found there (Table 5). Percentages are larger elsewhere, up to 41% in Toronto, though the sample size is clearly much smaller, as only a total of 79 respondents (9%) across the four cities reported using a fan without an air conditioner. Nevertheless, as a total of 22 respondents (2.4% of the total surveyed) responded that they had put themselves within a potentially lethal situation, the results are worth noting.

Table 5 Respondents' answers to whether the window was open when utilizing a fan, only aggregated for those who were not using an air conditioner

City	Yes	No
Dayton	8 (73%)	3 (27%)
Philadelphia	22 (85%)	4 (15%)
Phoenix	8 (80%)	2 (20%)
Toronto	19 (59%)	13 (41%)
Total	57 (72%)	22 (28%)

Miscellaneous comments

The responses to the final open-ended question relating to any additional comments generally fit into one of several themes. Most common were simple comments that they personally do not feel vulnerable or else feel highly vulnerable, as already addressed above. Among other themes, however, was one of concern about those other than the respondent, those in a worse-off situation, e.g.:

Heat doesn't bother me much but I worry about my neighbors, because they are worse than I am (Philadelphia)

Being retired is OK... Need better way to check on elderly, (such as) building a neighborhood watch type of scenario for those without a/c (Dayton)

A number of respondents, especially those in Toronto, commented on how this summer, in particular, was quite unbearable; considering eastern North America's lack of significant heat events in 2003 and 2004, summer 2005's above-normal heat was likely more offensive than would normally be the case, e.g.:

Normally we get 12 days over 90 (32°C) a year; this year is unusual. We're getting close to 30; normally it's not a problem (Philadelphia)

Several others cited cost as a primary concern:

The cost to survive is astronomic; the least amount of clothes doesn't keep you cool (Philadelphia)

It's difficult to try and stay on budget on hot days (Philadelphia)

Along similar lines, mostly Toronto residents cited the issue of energy conservation and the conundrum faced in terms of saving energy (and money) versus keeping cool.

There is a huge concern about saving energy but for some people there is a matter of life or death to have air. My apartment turns off air in the corridors. I can understand energy conservation... (Toronto)

For older people it is necessary. And other people with health problems and babies. And the problem is getting worse, such as the malls don't have air conditioning, also a lot of workplaces don't use air and it's bad (Toronto)

Others cited an acclimatization factor. This is most typical of Phoenix residents, many of whom proudly cited the number of years they'd lived there. For immigrants,

especially to those of Toronto, a feeling of being differently acclimatized also was expressed, e.g.:

This is cool to me; 122(50°C) is hot (Phoenix)

I came from a hot country, I have been used to the heat. Every year the heat is hot, you just prepare for it (Toronto)

Lastly, a relatively small subset of respondents cited using common sense along with recommended advice in terms of dealing with the heat, e.g.:

I basically consider if you follow guidelines and take care of yourself it can't become a problem. If I need it I get help (Dayton)

Use common sense (Philadelphia)

Discussion

In interpreting the results of the survey in light of the heat events and the mitigation plans, several points become clear:

Knowledge of the heat event is widespread, and likely due to pervasive media coverage Though the differences were statistically significant when the four cities were compared, overwhelming majorities claimed to know about the heat events in each of the cities. The majority of those that knew about the events learned about them via television, with radio a distant second. Interpersonal communication was much less common of a means than that of the mass media. Thus, it seems clear that the issuance of heat warnings and advisories are absorbed by the general public.

Though there is a clear widespread awareness, it is likely that there is considerable confusion among the respondents in terms of differentiating the official "heat warning" versus a "warning that it will be hot". This is manifested via the relatively minimal differences observed across cities in terms of the percentage of respondents that knew of the warning, despite the markedly different response plans analyzed in this research, inclusive of Phoenix, for which there is no municipal mitigation plan, only the messages released by the National Weather Service. With popular media eager to promote a timely news story, and media coverage of extreme weather events increasing (Ungar 1999), it is likely that all "hot" forecasts were discussed in detail on television. This is supported by the observation that statistically similar percentages of people knew about the heat alert in Philadelphia in June (when no mitigation

plan was implemented) as the excessive heat warnings later in the year (during which time the Philadelphia Department of Health exercised its mitigation plans).

Though knowledge of the heat was widespread, knowledge of details of the messages of the mitigation plans was markedly less so The bulk of responses suggested that “keeping hydrated” and “staying inside” were all that were needed. Far fewer mentioned avoiding overexertion, or the proper use of cooling, suggesting that either the population was not listening or not concerned, or that the media were focused upon those primary recommendations. If it is the former, it means that people do listen to the message that it will be unhealthily hot, but then seem to block out information, usually generated by local health departments, on what they should do during a heat episode. If it is the latter, possibly the intervention messages are too complicated, and the populace only absorbs the simplest of these pieces of information. It is difficult to assess which of these may be true, since across the varied mitigation plans described above, with certain individual exceptions (e.g., fan usage in Philadelphia), there was no clear connection between the detail of the message and what was recalled. Given that the popular media was by far the primary source for respondents, it seems clear that further training the media in terms of heat awareness and activities is the most effective way to increase overall awareness.

Relatively few people reported modifying their behavior because of the heat event Far fewer people acted upon the advice for dealing with the heat than recalled the advice, and most public actions were very limited. Most significant was the avoidance of the outdoors at all costs, along with a shifting of activities. Only half reported drinking more water when asked directly, and far fewer mentioned doing this explicitly in open-ended questions. Few of the respondents that regularly drink alcohol changed their habits.

Many respondents believe they are not vulnerable or the weather was not hot enough Based on the responses to several questions, there was an underlying theme of not being vulnerable to the heat. Though one cannot generalize about the health status of all respondents, very few admitted to having serious health concerns. Many felt that the messages were not meant for them, and 60% felt that the heat was either not a problem or only a slight problem for them personally. This sentiment was especially true in Phoenix, where open-ended answers suggested pride in the ability to regularly deal with hot conditions.

In all of the cities, it was discovered that respondents changed their behavior more when “it was hot” than

because of the heat warning. The differences were statistically significant in Phoenix and Toronto. In Phoenix, it is likely an acculturation to the hot climate, whereas in Toronto it may represent warning fatigue as the number of extreme heat alerts in 2005 exceeded that of any other year for which the system was operational. It also suggests that, in combination with the comments above, while many respondents knew that officially it was “hot”, they may base their personal response only on whether they personally feel overwhelmed by the heat.

Though air conditioning is nearly ubiquitous, economic considerations of the costs of electricity are important to a sizable percentage of the population More than one-third of all respondents, and nearly half of Toronto respondents, cited cost as a concern. Responses to this question suggest that few, if any, owned an air conditioner but did not turn it on at all, though a number expressed that they limited their usage due to the financial burden. As many respondents did not seem to recall many other recommendations, it should perhaps be emphasized to residents for whom this is a concern how to properly balance air conditioning with other means of reducing heat vulnerability, if the cost does prove prohibitive.

Municipal programs were cited by a number of respondents In both Toronto and Philadelphia, knowledge of the municipal programs available was cited by a number of respondents. Though the percentages were small (less than 25%), highly detailed information was cited by a number of respondents. In Toronto, the focus was upon the availability of cooling centers, whereas in Philadelphia, the focus included checking up on neighbors and the correct usage of fans. Interestingly, despite Toronto also having information available on the correct use of a fan, virtually no respondents cited this.

There is confusion among ozone precautions and heat precautions In both Toronto and Phoenix, ozone alerts coincided with the heat events, leading some respondents to cite that avoiding driving a vehicle helped them avoid the heat. In cases where a vulnerable person might be in need of a cooler location, he/she could potentially be confused if instructed not to drive.

There are several key limitations to the survey. By utilizing telephone surveys, the poorest and most isolated subsets of the population, those without telephone services or those least likely to answer the phone, may be underestimated. As such, the vulnerability described in these results is likely somewhat of an underestimate.

The language barrier is another key issue that has not been adequately addressed. A Spanish-language survey would

address the needs of the sizeable Mexican population in Phoenix. There also was no attempt at offering the survey in any of the Asian languages spoken by the diverse minorities in Toronto. Aside from any potential economic concerns about the subset of this population, dependent upon their English language skills or access to local native-language media, whether these populations would understand the heat warning information issued is a serious concern that could not be addressed here.

Last, the open-ended nature of a number of the questions within this survey was deliberate, so as not to coach respondents into identifying concerns or recommendations if they could not recall. Nevertheless, there were over 9,000 open-ended answers that had to be interpreted and categorized, and while most were relatively easy to categorize, misinterpretations of questions, vague answers and the occasional inadequate transcription lend some uncertainty to the overall results that cannot be accounted for.

Recommendations

Based on the above results, key recommendations are:

Increase advance training of the media on the heat Since the ultimate source of heat information for the majority of the population is television, resources should be directed into keeping the media informed ahead of the summer about the effects of and ways to deal with the heat. Most specifically, the on-air meteorologists should be trained to understand fully the HWWS, as well as the health implications. The media should be encouraged to detail more means of avoiding the heat than just avoiding the outdoors. This would be of significant utility to those who, as discussed above, have financial concerns, as well as the entire population should a power loss occur.

The general public should be made aware that watches/warnings are based on human health responses The results indicated that most people did not think that during excessive heat warnings the weather could be harmful to them. Clearly, it has not been conveyed to the general population that the issuance of heat warnings is based upon a general deterioration in population health, and in the case of the synoptic-based HWWS, increased mortality during similar situations in the past. In addition, the results show that many people usually did a self-determination as to whether it was hot, rather than relying on the official warnings. Both of these factors represent problems in

perception, and a means should be established to address these problems.

Expand efforts to relate people's vulnerability Although the local media often list the most vulnerable type of people when it comes to heat (the elderly, those on medication, etc.) it is clear that this message is not getting through. Thus, many people are not personally taking the warnings seriously enough, and health departments, along with other stakeholders, need to be responsible in getting this message across.

Expand explanation on the correct usage of fans Though this issue is a component of the three cities studied that have a mitigation plan, only in Philadelphia did the population appreciably cite knowledge of the correct usage of a fan. Municipalities should place more emphasis on explaining *why* running a fan with the windows closed can be deadly, and be sure that the media and all civic agencies are well trained in how to relate this information.

Clarify the difference between ozone precautions and heat precautions All media and civic agencies should be instructed to clarify that precautions for dealing with ozone (such as not driving a vehicle) do not relate to the heat, and that if necessary, driving to a cooler location is much preferred to not driving. There has long been a debate as to whether there should be separate pollution and hot weather warnings. Some standardization is necessary here, as well as a determination on whether separate pollution and heat warnings should be issued on hot days.

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