Are America's Cities Ready for the Hot Times Ahead?

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ABSTRACT

The purpose of this research is to learn how city governments, human services departments, and community organizations can reduce the impact to human health from summer heat waves in U.S. cities. The city of Chicago developed its *Extreme Weather Operations Plan* to reduce the impact of heat waves after the tragedy experienced in 1995 when over 500 people died from excessive heat exposure (heat stroke). Another U.S. city, Philadelphia, developed a heat warning system, the *Philadelphia Hot Weather Health Watch/Warning System*, which used climate data and human mortality data to identify hazardous air masses (heat waves) that have the potential to elevate human mortality within the city. For this research, the case studies conducted on Chicago and Philadelphia will focus on the meteorological characteristics of a past heat wave such as length of time (days/weeks), high temperatures, low temperatures, heat index, and dew point temperatures. Then for each case study the impact on human health will be assessed. This study will be looking at heat wave mortality from exposure to excessive heat as well as mortality from other illnesses further complicated by exposure to excessive heat. Finally, this study will focus on how the heat warning systems used in Chicago and Philadelphia were able to reduce the impact to human health during heat waves and how these systems can be improved and used in other U.S. cities.

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INTRODUCTION

Slow and silent, a heat wave does not descend upon a city with the fury of a tornado, hurricane, or a winter storm. It moves over an area as a large, deep air mass with descending air, retarding the development of any significant precipitation that would provide relief to the ground surface's rising temperatures. As this air mass moves slowly or just sits over one area for days or even weeks, its rising surface temperatures begin to take their toll on the people who are trapped in it.

Although, heat waves are not often taken as seriously as other forms of severe weather, the mortality from these weather events in the U.S. from 1979 to 1998 is greater than the number of lives claimed by lightning, hurricanes, tornadoes, floods, or earthquakes combined (National Center for Environmental Health) (Fig. 1). Even during a normal year without a catastrophic heat wave, the National Weather Service claims that an average of about 175 people succumb to summer heat. This number does not include the number of excess deaths of people already in poor health, whose deaths may have been advanced by exposure to extreme heat. Despite the presence of improving technology (e.g. air conditioning, architectural design, and improved accuracy in weather forecasting), heat waves continue to take many lives. From the early 20th century to the present time, Americans have experienced a significant rise in the cost of property damage from severe weather events, at the same time the number of lives lost has decreased. Unfortunately, it appears that heat waves have not followed the same trend.

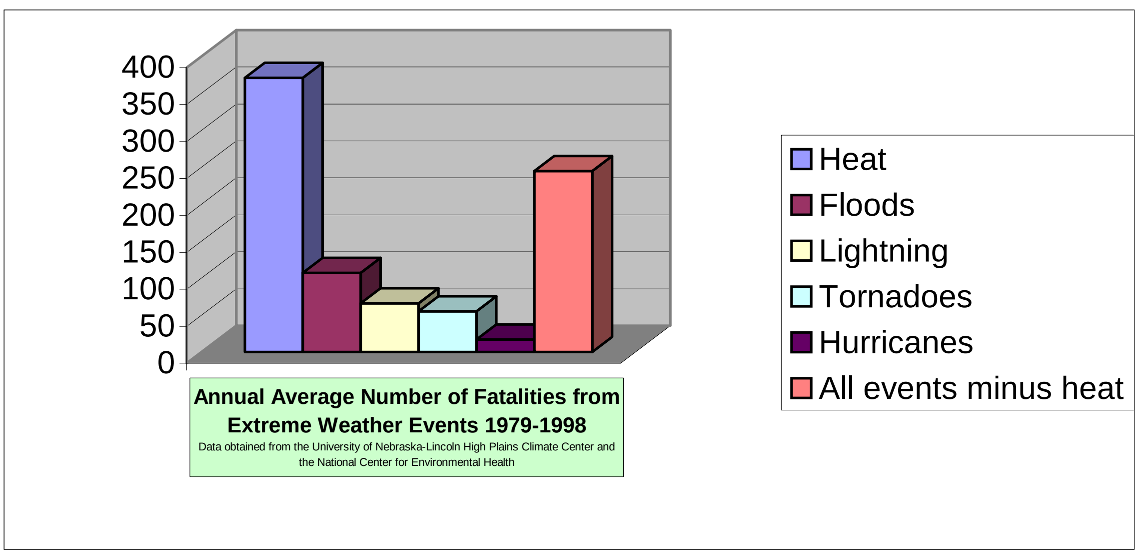

Fig. 1. Annual Average Number of Fatalities from Extreme Weather Events 1979-1998.

Aside from being a major health hazard, heat waves also put heavy stress on our energy resources. It is often the case when an intense heat wave occurs, thousands or even millions of people in a given region run their air conditioners at the same time.

During past heat waves, power companies have often had to engage in a series of “rolling blackouts” to prevent a total blackout over the affected region. This is a critical issue, because if a total blackout occurs over a given region, the heat wave then becomes a health hazard to the entire population.

Like all other major weather events, we cannot prevent a heat wave from developing. We should, however, give serious consideration to how our communities deal with heat waves when they occur. In addition, there are a number of other reasons why we should care about how we deal with heat waves. First, it is often the case that many fatalities during even the most severe heat waves occur after the first day of extreme heat. This means that there is time to help people who do not have, or cannot afford, air conditioning. People in the U.S. over 65 years old are especially vulnerable to extreme heat, and this population is expected to grow in the very near future. Heat waves of the past have often been more intense in urban areas. This is a real problem because Americans are continuously migrating to urban areas. This trend suggests that more people would be at risk when a heat wave occurs in the region, power companies would be heavily stressed trying to keep more people cool, and “urban heat islands”(urban areas where heat is retained by a high density of man-made structures) would be created, or enhanced if they already existed in the region. Scientists have observed the average global temperature increase by the end of the 20th century. As global warming continues it could increase the probability of more frequent and more intense heat waves. This poses an even greater problem for northern cities in the U.S., where people are not accustomed to long periods of high heat. Finally, there are a few other societal impacts to be considered such as: water usage (heat waves often occur during droughts), urban pollution building up during heat waves, and the economic impact (the cost to keep millions of people cool).

This paper will focus on past heat waves that recently occurred (within the past 6 years) impacting U.S. cities in the Midwest and the Northeast. The first topic that will be assessed is how were certain cities in the Midwest and the Northeast impacted by severe heat waves. Next, is to observe how different cities dealt with the heat wave to reduce the health impacts to the population. The development of heat warning systems or the upgrading existing heat warning systems will be looked at to note the effectiveness of the systems in saving people’s lives. Finally, this study will attempt to provide more ideas that could help reduce the impacts of heat waves in the cities of the Midwest, the Northeast, and could possibly be applied to other cities across the U.S.

RESOURCES AND METHODS

As a first step in the research of summer heat wave in the United States over the past decade, meteorological and social data were obtained from a wide range of sources. These data were compiled and used to compare characteristics and impacts of heat waves that affected various cities across the country.

Case studies of two cities, Chicago and Philadelphia, were examined for the summers of 1995 and 1999 in Chicago and 1995 in Philadelphia. These two cities were chosen because in 1995 they were the two cities where the Midwest and Northeast Heat Wave was the most intense (Chicago and Philadelphia reached apparent temperatures over 120 F and dew point temperatures above 80 F). Philadelphia was also examined in 1995 because during that heat wave the city applied its new heat warning system. A second case study was conducted on Chicago for the summer of 1999. Since the 1995 Heat Wave had a tragic impact on the city of Chicago, the city developed a new heat warning system, which was applied during an intense heat wave in 1999. These case studies look for how city governments, community organizations, power companies, National Weather Service Office, and human services departments worked together to reduce heat wave impacts on human health.

These studies also explored differences in the heat wave events, such as the actual temperatures that were considered normal, the “threshold apparent” temperature used to issue a heat warning for the public, and the time period for an event to be considered a heat wave. For both cities, data were assessed using variables such as “apparent” temperatures, dew point temperatures, actual high & low temperatures, and the development of the heat wave (development of ridges, enhancement of areas of high pressure, moisture sources, and the role of an urban heat island effect.)

This research also explored high nighttime temperatures and nighttime apparent temperatures. The duration of high nighttime temperatures was assessed to show how high nighttime temperatures adversely affect people without air conditioning because of lag time in the nighttime cooling of urban dwellings. Nighttime temperatures were also important to look at a city’s “heat island effect” and how it contributed to the impact on human health. Meteorological data were obtained from the National Weather Service website, and several papers published in the *Bulletin of the American Meteorological Society*. Other sources that were used to collect meteorological data were obtained online from web pages created by Illinois State Climatologist, Jim Angel & Illinois State Water Survey, National Oceanic and Atmospheric Administration, and the National Weather Service.

This research also examined the societal impacts of heat waves on human mortality, the stress on emergency services, and the ability of utility companies to provide power to their customers during these events. We learned that the actions taken by city governments, human services departments, and the NWS offices were crucial to the reduction of impacts from a heat wave while it was occurring. This information was obtained from local newspaper articles (*Chicago Tribune, The Times Union, and The Philadelphia Daily News*) communications with climatologists and meteorologists, and other documents that supplied information about a city’s heat wave response system. We used national newspapers and newsletters such *The New York Times, USA Today,* and

CBS Newsletter to find information about severe heat waves that affected one or both of the cities in 1995 and 1999. There were also sources collected online relating to the impact of the heat waves on mortality created by Steven Whitman, Glenn Donoghue, Edmund R. Benbow, Michael A. Palecki, and Stanley A. Changnon.

RESULTS AND CASE STUDIES

The Development and Meteorological Characteristics Of the July 1995 Heat Wave

As typical of many heat waves that develop in the central United States, the heat wave during July of 1995 was the result of a strong upper-level ridge shifting eastward due to a deepening trough over the Northwestern U.S. This ridge resulted in a powerful area of high pressure in the mid-troposphere (Palecki et al. 2001), and as it progressed slowly eastward, subsidence of air (descending and compressing air) heated the ground surface over a large area beneath the ridge. As the air temperature near the ground surface increased, the area of high pressure expanded upward pushing the 500 millibar level past its normal July geopotential height creating an incredible mass of heating, subsiding air (Palecki et al. 2001). On July 10th parts of Kansas were over 104 degrees F as the center of the high approached aloft from the southwest (Kunkel et al. 1996). As the ridge progressed eastward its moisture content increased near the ground surface. First, advection (horizontal movement) of air from the Gulf of Mexico pumped warm, moist air northward on the western side of the high-pressure area. Secondly, the five feet soil profiles had been abnormally moist over northern Missouri and southern Iowa (Livezey & Tinker). The ridge continued to advance to the west slowly allowing ample time for intense surface heating and solar radiation to instigate evaporation from the soil further saturating the air. By July 13th the ridge covered the eastern half of the U.S. and the area of high pressure, reaching its maximum intensity, had centered itself over Illinois (Kunkel et al. 1996). From that point the area of high pressure started to weaken as the ridge advanced to the Northeastern U.S. Although the area of high pressure had weakened significantly by July 15th, the hot, humid air it possessed moved through the Mid-Atlantic region producing dangerous heat indices from Massachusetts to North Carolina. The heat wave persisted over the Mid-Atlantic region until August 8th.

The city of Chicago felt the maximum impacts from the heat wave on July 13th and 14th. The two-day average temperature at Chicago Midway Airport (inner city location) on the 13th and 14th of 93.5 degrees F was the highest in the past 48 years of record prior to 1995 (Livezey & Tinker 1996). O'Hare International Airport (outside Chicago) recorded slightly lower temperatures, however, this location had the highest two-day average in the past 38 years of record prior to 1995. On July 13th high temperatures at O'Hare International Airport reached 104 degrees F, and 106 degrees F was reached at Midway Airport. The heat combined with the high moisture content of the air produced an apparent temperature (heat index) of 118 F at O'Hare International Airport (Kunkel et al. 1996). The coolest 24-hour temperatures reached on July 14th were 83 F at O'Hare International Airport and 84 F at Midway Airport (Livezey & Tinker 1996). The slight difference in temperatures indicated the presence of a heat island during the event. The dew point temperature in Chicago remained above 77 F from midnight on July 12th to July 15th with maximum dew point temperatures reaching 79 F at O'Hare and 83 F at Midway during that time period (Livezey & Tinker 1996).

Philadelphia, downwind of Chicago, felt the heat wave's greatest impact on July 15th. The morning low in Philadelphia on the 15th started at 81 F, and a high of 103 F was reached in the afternoon (Philadelphia Climate Data, NWS 1995). On that day a sweltering apparent temperature of 129 F (Philadelphia Daily News 1995) was reached, which means that the dew point temperature was at least 81 F and relative humidity was 51% (NWS Weather Calculator). On July 16th temperatures were 12 F cooler in the afternoon than they had been on the afternoon of the 15th. However, the daytime low temperatures remained at 70 F or above for the next 21 consecutive days, and daytime highs remained at or above 89 F for the next 20 consecutive days (Philadelphia Climate Data, NWS 1995). The temperature distribution for Chicago and Philadelphia during the 1995 Heat Wave is shown in Table 1.

Table 1. Actual high (MaxT) and low (MinT) temperatures measured at the Chicago Midway Airport and the city of Philadelphia for the period from July 12th to July 16th. Maximum apparent temperatures (Max T_{ap}) calculated for both cities are shown in bold italic. Table taken from: *Some Meteorological, Climatological, and Microclimatological Considerations of the Severe U.S. Heat Wave of Mid-July 1995.* Robert E. Livezey and Richard Tinker, Climate Prediction Center, NCEP/NWS/NOAA, Washington, D.C. 1996

Date (July)						
Station		12th	13th	14th	15th	16th
Chicago Midway Airport	MaxT.	97	**106**	102	98	93
	Max T_{ap}		***125***			
	MinT.	75	81	**84**	77	76
Philadelphia	MaxT.	91	94	98	**103**	91
	Max T_{ap}				***129***	
	MinT.	70	74	76	**81**	74

Impacts of the 1995 Heat Wave in Chicago and Philadelphia

In Chicago the heat wave lasted only six days, however, the impacts on human mortality from this brief period were catastrophic. Electrical utilities also felt a heavy impact from the event. On Chicago's Northside 40,000 customers lost electric power on the night of July 14th and 8,500 of those customers remained without power through July 15th (Changnon et al. 1996). The local power company, Commonwealth Edison, issued rolling blackouts throughout the rural and suburban areas to keep power within the city of Chicago. On July 14th 19,200 megawatts of power were used, which was a record high for the city (Changnon et al. 1996). The mortality reached its peak daily total on July 15th (third day of the heat wave) with 181 heat-related (heatstroke) deaths (Huang, CBS Newsletter 1996). By July 20th the Chicago Department of Public Health reported 498 heat-related fatalities from the heat wave. On August 2nd the total number of heat-related fatalities within the city of Chicago amounted to 525 (Whitman 1995). Another 208 fatalities were from excess deaths, which are deaths from other health problems further complicated by excess heat exposure. Serious heat-related illnesses (heat stroke & heat exhaustion) sent thousands to Chicago hospitals overwhelming the hospitals' staff and ambulance services (Changnon et al. 1996).

In Philadelphia the heat wave's most intense period only lasted two days (July 14th and 15th). However, an incredibly high apparent temperature of 129 F was reached on July 15th, and three weeks of hot weather followed the heat wave's peak (Philadelphia Daily News 1995). The heat wave impacted Philadelphia in some of the same ways that it impacted Chicago. On July 15th 30,000 Peco Energy Co. customers lost power as transformers overheated and circuits overloaded (Philadelphia Daily News 1995). That same day the power usage was at 6,959 megawatts, which was a record for weekend usage in Philadelphia.

The heat wave's impact on mortality in Philadelphia was different than the impact in Chicago. During the entire hot period (July 13th-August 14th) 72 people lost their lives. This number included the number of people who died from heat-related illnesses as well as the number of excess deaths reported. Philadelphia has a smaller population than Chicago (1.5 million compared to 2.7 million). However, despite the difference in population, the mortality rate during the heat wave in Philadelphia was still significantly less than in Chicago.

Taking the Heat in Philadelphia:
Philadelphia's Hot Weather-Health Watch/Warning System:

During the summer of 1993 an 11-day heat wave ended the lives of 118 people in the city of Philadelphia. After that summer the Philadelphia Department of Public Health worked in cooperation with the National Weather Service to develop a more effective heat warning system. This new system was developed because it was found that certain factors were left out when only the apparent temperatures were used to issue excessive heat warnings.

The current excessive heat warning systems in most U.S. cities use the NWS guidelines, which use the apparent temperature to determine when to issue heat warnings (Kalkstein et al. 1996). Basically, an excessive heat warning is issued by the NWS if the forecast is expected to have apparent temperatures above 105 F for more than three hours for at least two consecutive days, or if the apparent temperature is expected to reach 115 F at any point in the forecast. One of the problems with only using the apparent temperature to issue warnings is the "apparent temperature concept" can itself be very confusing to some people unfamiliar with atmospheric science. For example, an excessive heat warning is issued for a city that is forecasted to have an apparent temperature of 105 at least three hours a day for two days in a row. If New York City is forecasted to have an actual temperature of 98 F with 45% relative humidity for two consecutive days, it is a candidate for an excessive heat warning because that would place its apparent temperature around 109 F. However, if El Paso, TX has actual temperature 109 F with 10% relative humidity for the same time frame it falls short of an excessive heat warning because the apparent temperature would be 104 F. What can confuse people is not realizing an apparent temperature of 109 F in New York will pose a greater health hazard than an actual temperature of 109 F in El Paso.

The Philadelphia Department of Public Health (PDPH) took a different approach by using more meteorological variables to identifying hazardous conditions associated with heat waves that occur in Philadelphia. The PDPH used studies conducted by the U.S. Environmental Protection Agency (EPA) and the Southern Regional Climate Center as a basis in creating the Philadelphia Hot Weather-Health Watch Warning System (PWWS) (Kalkstein et al. 1996). These studies linked elevated mortality with days when oppressive (hot & humid) air masses were present. From the conclusions of these studies the PWWS established a goal to identify hazardous, oppressive air masses. Then the PWWS alerts the public and health agencies that these oppressive air masses have been predicted and are likely to impact the city.

The PWWS is sophisticated because it uses more than just apparent temperature in identifying heat wave conditions or oppressive air masses. The six meteorological characteristics of air temperature, dew point temperature, cloud cover, sea level pressure, wind speed, and wind direction are used by the PWWS to identify air masses that are typically present over the Mid-Atlantic region (specifically the Philadelphia area) during the summer (Kalkstein et al. 1996). From the eleven air masses that typically occur over the Mid-Atlantic region, the Maritime Tropical Oppressive Air Mass (MTO) is the air mass that is most often associated with elevated human mortality during the summer (Fig. 2). However, the presence of an MTO does not mean that elevated mortality is imminent during the day (days) of its presence. This is when the PWWS takes further steps to assess if the air mass is hazardous. The six meteorological characteristics are further assessed four times daily for MTOs and are compared to mortality data during the presence of MTOs. This is to determine what conditions or thresholds make certain MTOs more or less hazardous to the Philadelphia population.

During the summer the PWWS is a triad consisting of the PDPH, the NWS office for the Philadelphia area (Mount Holly NJ), and Delaware's Center for Climate Research (DCCR), all of which work together to keep a watch out for MTOs moving into the Mid-Atlantic region. NWS data is used to forecast an MTO up to 48 hours in advance of its anticipated arrival (Kalkstein et al. 1996). If an MTO is anticipated to arrive within 48 hours of a forecast, a Health "Watch" is issued for Philadelphia by the PDPH. A day later another NWS forecast is assessed by the PDPH 24 hours in advance of a MTO's anticipated arrival. If an MTO is still expected to arrive 24 hours after the forecast, the PDPH issues a Health "Alert." In preparation of the MTO's arrival the PDPH and the

DCCR observe the six meteorological characteristics of the MTO every six hours to determine if the conditions are severe enough to cause elevated mortality in Philadelphia. If elevated mortality is predicted the PDPH and the DCCR recommend the issuance of a Health "Warning", which must have the concurrence of the NWS (Kalkstein et al. 1996). With a Health "Warning" issued steps are taken by the PDPH, Peco Energy Co., Philadelphia Water Department, city hospitals, Philadelphia Fire Department, homeless services, and the Philadelphia Corporation for Aging to reduce the health impacts and mortality of Philadelphia's population during a severe heat wave.

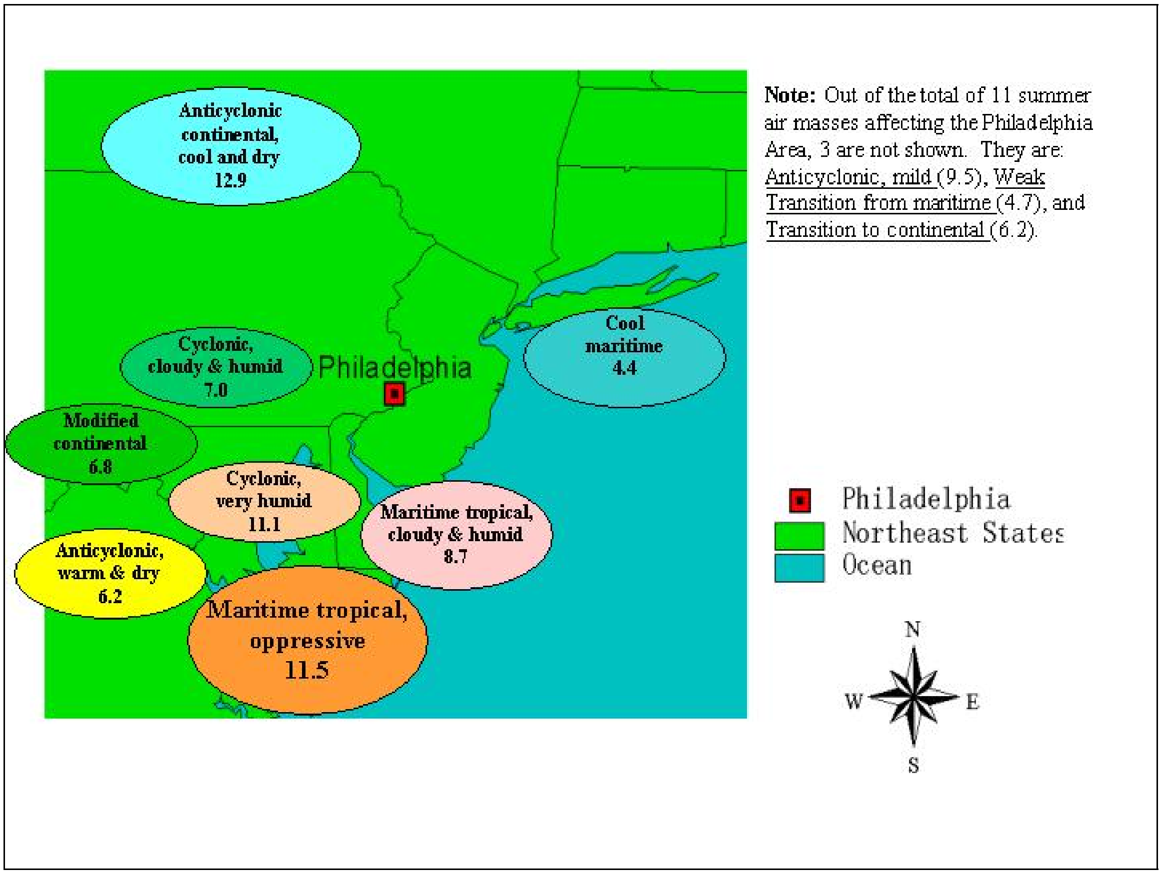

Figure 2. Summer Air Mass Types in Philadelphia. Information for map obtained from: Kalkstein, et al., *The Philadelphia Hot Weather-Health Watch/Warning System: Development and Application Summer 1995*

The PWWS is very unique in the way it customizes it's heat warning system to identify MTO's (heat waves) that would jeopardize the health of the people in Philadelphia. It can be described as somewhat of a "grass roots" approach at the city level to identify the risks to and the needs of the people specifically for Philadelphia. This heat warning system has been customized by other cities to apply to their population's needs and identify who and what is at risk. The cities that have adopted this approach to customizing heat wave warning systems in the U.S. are New Orleans, Phoenix, SW Ohio Region (Cincinnati), and the International cities of Rome, Shanghai, and Toronto (Kalkstein, personal communication).

Chicago's Heat Wave Mitigation Plan:
Saving Lives during Heat Waves

After the 1995 Heat Wave in Chicago the Mayor's Office, City Council, and the Chicago Health Department came together to develop a new "heat warning plan" (Changnon et al.). By the fall of 1995 the city of Chicago had its *Extreme Weather Operations Plan*, which included mitigation steps for the city to take during heat waves to reduce the impact to the city's population. The participating agencies and human services departments in Chicago's heat warning plan are shown in Fig. 3. The NWS first anticipates a "heat warning" if the forecast calls for: a heat index of 100-105 F for three consecutive days with 85% sunshine 2 of the 3 days or a minimum heat index of 74 F each day, two consecutive days of a heat index of 105-110 F, or one day with a heat index greater than 110 F. The anticipated warning is preceded by a "heat watch" (Labas, NOAA NWS). As soon as a heat watch or warning is issued by the NWS, the Chicago Fire Commissioner is put in charge of mobilizing the city service departments in preparation for the heat wave. The Mayor's Office of Inquiry and Information distributes 500,000 brochures on how to register to receive a "well-being check" for oneself, a neighbor or other loved ones. Other human services departments are in charge of carrying out well-being checks, providing cooling centers, checking buildings for proper ventilation, monitoring nursing homes and hospital emergency rooms, watching for all citizens at risk (the elderly, families, and people with preexisting health complications, who do not have air conditioning or people who work outside) from excessive heat exposure, and distributing "Heat Tips" brochures with information on how to stay healthy during a heat wave (Mayor Daley 1996).

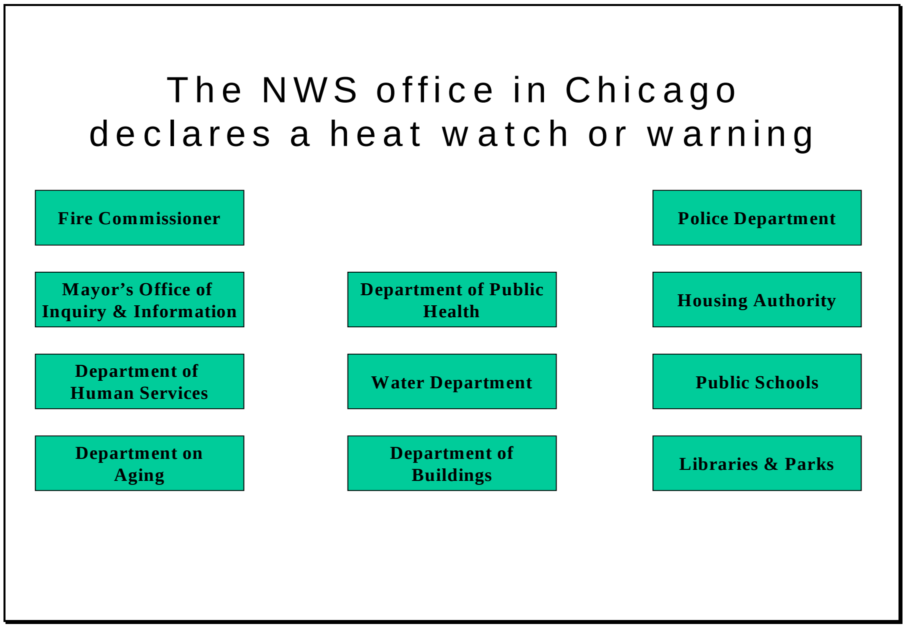

Fig. 3. Participating agencies and human services departments during a heat warning in Chicago.

During the last third of July 1999 the Midwest experienced a heat wave that was nearly as intense as the 1995 Heat Wave as far as heat indices within cities, especially Chicago. In preparation for the heat wave the city of Chicago started its *Extreme Weather Operations Plan* on July 22nd after the NWS forecasted a heat index of 110 F for July 23rd. The city opened 65 cooling centers, using schools and other facilities and provided free bus service to these centers (Palecki et al. 2001). In addition to the buses the city provided round-the-clock drivers for people who needed to go to a cooling center (Chicago Tribune 1999). From July 21st to the 25th more than 30,000 elderly people were visited by the Department of Aging, the Chicago Housing Authority, and other city agencies. After a cool period on July 26th and the 27th the heat quickly returned. On July 29th the NWS issued an "excessive heat warning" and the *Extreme Weather Operations Plan* was quickly put back into effect by the city. As the heat index pushed up to 120 the City of Chicago's human services departments worked overtime conducting well-being checks, monitoring hospitals and senior facilities, and moving the people most at risk to cooling centers. That day more than 1000 people were brought to the city's cooling centers (Palecki et al. 2001).

DISCUSSION ON HEAT WAVE RESPONSES

It is difficult to compare the tragedy of the 1995 Heat Wave in Chicago with the impacts and the response to the 1999 Heat Wave. When the actual mortality numbers from the 1995 and 1999 Heat Waves in Chicago are assessed, it is noticeable that in the city over 500 people died from 1995's heat wave as compared to 93 people who died during the 1999 Heat Wave. Ninety-three people is still a tragic loss of life so this case study does not look at the *Extreme Weather Operations Plan* as the solution to the problem of heat waves but rather as a step in the right direction to save lives. The same can be said for the *Philadelphia Hot Weather-Health Watch/Warning System.* The system was effective in identifying hazardous air masses and mobilizing human services departments, however, during the 1995 Heat Wave in Philadelphia there were still 72 people who succumbed to health impacts of the heat wave.

In taking steps to further reduce the impacts that heat waves have on the populations in U.S. cities, there was much to be learned from these two case studies. In the case of Philadelphia, we emphasized the identification of which weather conditions or air masses that posed the greatest health hazard for the city. Next, we examined Chicago's focus on mobilizing city human services departments to check on people throughout the heat wave's duration. As the next step in solving the problem, we had to ask, "Why did 72 people lose their lives in Philadelphia or 93 people in Chicago while these heat wave warning systems were in place, or why weren't these people reached?"

Heat Waves do pose a definite health hazard, however, and social conditions are major players. People with high incomes who can afford to set their air conditioners on "high" are not the ones dying during heat waves. The people who are not reached are the elderly who live alone in the poor, high crime neighborhoods in the city. They keep their windows closed so no one will break in. They cannot leave to go to a cooling center because when they do everything they own in their home could be as good as gone when someone breaks in and steals everything. Also, there are still problems with getting information out to the public. Often with any nature disaster impacted a city, it is not considered that my U.S. cities have large communities of Spanish-speaking people as well as communities where many people speak languages other than English or Spanish. Some families living in inner city apartments do have air conditioners, but won't turn them on because they do not realize that with the heat warnings in effect, the government will subsidize the extra cost to run the air conditioners during heat waves.

With the problems that still exist in dealing with heat waves in U.S. cities at the community level, further solutions should come from the community level. In the case of Philadelphia both the NWS and Department of Public Health cooperate to reduce heat wave impacts, and in Chicago the city government and human services departments also work hard to reduce impacts. However, what we have learned from these studies is that further solutions may come from community organizations working to reduce heat wave impacts. For example, if people are scared to leave their homes to go to cooling centers, members of a community organization who are less at risk from heat could watch their homes while they are gone. It would also be easier for community-based organizations to conduct the door-to-door checks on people for two reasons. First, they live in the community so they are not going out of their way to a strange neighborhood, and they may already know, personally, who is most at risk during at heat wave. Second, they are likely to know the people they are checking up on and last; they take some of the burden off the city human services departments so they can tend to other problems associated with the heat wave. Once mobilized, a community heat wave response organization can also work with the city human services departments. An example of this can be seen in San Leandro, California's "Triad Alliance" where community-based organizations, emergency management departments, and the city government work together to mitigate disasters associated with earthquakes (Lunsford, 2000). In the case of heat waves, the city government or mayor's office could still facilitate the registering of people for well-being checks, but then distribute the lists of people to be checked to the community organizations.

The challenge with developing community heat wave response organizations is finding enough dedicated members to assist during heat waves or keeping the organization prepared and ready to mobilize during the warmer parts of the year in U.S. cities. This is a challenge because, as stated in the beginning of this paper, heat waves are different in nature than other forms of severe weather or disasters. For example, an earthquake or a hurricane occurring in a city disrupts life for a wide range of people. If peoples' communities and workplaces are damaged people have little choice but to stay and help each other. In the case of heat waves, aside from occasional power outages and buckling of some roads, peoples' daily lives continue as normal. People go to work, or school, fitness-focused people exercise out in the heat, and kids play outside. The impact is not obvious because the people who are suffering the most are hidden in their apartments/homes day and night, or they work hard all day and the health effects from the heat are felt at night when their homes are still hot from the daytime.

More people will start to care and form community heat wave response organizations if they are educated on how hazardous heat waves can be. This will increase peoples' involvement the next time a heat wave threatens their community. As far as "who" should make up the organization, everyone from youngest to oldest should get involved. Elderly who are in good health should also get involved in these organizations. This is important because many elderly people are retired and can put time into mobilizing a community organization during a heat wave. Also, there are many people at risk who would often refuse to leave their homes with a stranger checking up on them, but might be convinced by a close friend to go to a cooler place if their health is in jeopardy. Education programs could also be given in schools. This way children and young adults can participate in the community organizations and are aware of the risks of excessive heat exposure to young people (over exertion during excessive heat periods). Some younger people and employers would have to make sacrifices during a heat wave to put work aside and mobilize the community organizations to deal with the situation. Looking at a whole city during a heat wave, we can compare it to a person. When there is excessive heat occurring a doctor would probably tell a person to rest and "take it easy." The same could be said for a city as a whole, to slow down during a heat wave and of course continue to function but allow communities to come together to keep their people safe during a heat wave. Chicago Mayor Richard M. Daley mentioned the importance of the whole city's cooperation in his 1996 Summer Heat Preparedness Speech, "I want to continue to stress, however, that the City's efforts alone cannot prevent the tragedies related to extreme heat. We need everyone to get involved." (Daley 1996)

CONCLUSIONS AND FUTURE RESEARCH

The goal of this paper was to tell a story of two cities, educating a broad audience on what happened in Chicago and Philadelphia during severe heat waves and how these cities developed plans “to keep the most at-risk people safe” during heat waves. Another goal was to assess areas that needed improvement in the cities’ heat wave response plans and provide new ideas for dealing with heat waves at a different level than city government or human services departments. The heat waves in Chicago and Philadelphia were definitely extreme events, but since severe heat waves could occur in these to cities it is not inconceivable that severe heat waves of the same nature (80 F dew point temperature, 120 F apparent temperatures, and minimum temperatures above 80 F for a couple or several consecutive days) could impact Minneapolis, Cleveland, Pittsburgh, New York City, Boston, or other cities in the Midwest and the Northeast. All of these cities may benefit and learn from Chicago and Philadelphia on how to design effective heat warning systems or improve the heat warning systems they may already have. It can also be stressed in Chicago, Philadelphia, and all the other cities designing heat wave warning systems; these systems must include mobilization by the NWS offices, city governments, human services departments, and community organizations to more effectively reduce the impact of heat waves.

Future Research

The focus of this research project was to assess the impacts of heat waves in cities located in the U.S. Midwest and the Northeast. It is my intention to expand this study to the rest of the country. In studying the impacts of heat waves in general it can be seen that the impacts of heat waves vary in different areas of the U.S. For example, three consecutive days with a heat index above 105 F may have similar impacts in Boston and Dallas, but there may be different impacts when the variables of structural density, the population’s access to air conditioning, and acclimatization are considered. The same could be said about New York and Los Angeles. While New York experiences humid heat waves, similar to Chicago and Philadelphia, elevating mortality, Los Angeles often experiences dry heat waves elevating mortality somewhat but having a greater impact from winds and wild fires accompanying the heat wave. For future study I intend to study who/what is at risk in U.S. cities in the West, Southwest, and Southeastern regions of the U.S.

Another future research project that is well deserving of attention would be to assess how populations, urban or rural, deal with excessive heat. Many lessons could be learned from this type of study. There are many countries or regions across the globe that experience hotter weather than even the hottest regions of the U.S. In some cases, in affluent societies, when heat waves occur, most people have air conditioning or need air conditioning to remain healthy. In other countries, especially in or near the tropics, air conditioning is not accessible to everyone, but people live their lives without it. Some questions that can be asked are, " Are these populations acclimatized to their environments and the people have higher thresholds for heat? Do these people experience the same impacts from excessive heat that people with no access to air conditioning in the U.S. do, or could the impacts be even greater and no one as yet realizes it? If there are severe health impacts from heat how do the people in other countries work to reduce those impacts? How has the "PWWS" type of heat warning systems worked in Rome, Shanghai, and Toronto?"

A final area of research could focus on heat waves and global warming. In the 20th century we have seen an increase in the average global temperature as well as a phenomenal increase of a major greenhouse gas, carbon dioxide. In addition, we should ask if the earth's cities or the entire human population of the earth should be prepared for a warmer climate with more frequent heat waves in regions where they were once rare, and have cities prepared for more intense (hotter) heat waves? This topic is very deserving of study because we have seen the global temperature increase, and across the globe in developed and developing countries people are moving to cities. If these trends continue, the global community could learn from each other on how we all can live comfortably in a warmer world.

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