

R E V I E W

# Heat-Related Death

*Risk Factors and Prevention Strategies*

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## **Summary**

In the northern states, low-income energy efforts have traditionally focussed on heating issues. Today, there is a growing concern for supplying cooling to low-income customers to prevent heat related deaths. Concern is heightened in the Midwest by the unusually high number of heat related deaths in Milwaukee and Chicago during July 1995.

Although heat waves in the Midwest are relatively rare, various groups are taking measures to prevent a repeat of the summer of 1995. The longer term success of these initiatives may, ironically, depend on the frequency of heat waves. If the heat waves remain infrequent, institutional and popular memory is likely to fade with respect to the dangers.

This report presents an overview of the heat related deaths of 1995 in Chicago and Milwaukee, explains the risk factors of heat related deaths, and discusses strategies to avoid a repeat of the 1995 heat related deaths. Also noted are needs for future research. This summary provides a brief overview of the findings of each section of this report.

### **Risks of heat related deaths**

There are two types of heat related deaths. One, when heat is the primary cause of death, such as heat stroke, or two, when heat exacerbates an existing medical condition, contributing to the death. Studies of the 1995 heat related deaths reveal that there are many intertwining factors influencing an individual's susceptibility to heat. Age, health and social situations all play a role. The elderly are particularly at risk.

In the case of Milwaukee, there is a pattern to the heat related deaths of 1995. Most cluster in a few zip code areas. Census data reveals that these areas have higher levels of poverty than the city as a whole. The exact reason for the disparate distribution is

unknown. The ability to purchase air conditioners or the conditions of the homes are two possible factors.

Overall, no single strategy is sufficient to reduce heat related deaths. Education is key, but physical measures may be required to help people unable to act on their knowledge. The direct aid should be focussed on the elderly and disabled members of the community, especially those with low or fixed incomes.

### **Strategies**

Technology, social contact or both characterize strategies to avoid future heat related deaths. Each type has strengths and weaknesses. Technological strategies would keep people cooler, but could be quite expensive and/or may miss many of the most vulnerable. Addressing social isolation or other social factors may be less expensive and reach more people, but do nothing to address the fundamental heat issue. A combined approach may be most effective.

In Milwaukee, the Health Department has developed a heat emergency plan. The heat emergency plan focuses on preparing concerned agencies for hot weather and outreach to those in need. The result is a “network of networks. Forecasts of hot weather warn public health and safety agencies to prepare for emergency measures. Social agencies are notified and encouraged to check on elderly members of the community. Doctors encourage elderly patients to sign up for “check-in” lists. The general public relies on the local media to provide warnings about impending heat and protective measures they can take. Overall, the emphasis is on short-term heat management.

Philadelphia has made similar efforts. “Block captains” exist throughout the city, a fortunate cultural aspect. The Block captains organize neighborhood beautification projects. The city’s Health Department reminds the block captains each spring and again

during forecasted hot weather to check on the elderly members of their neighborhood. Additionally, the media educates the public about the dangers of heat through the promotion of heat indexes and heat health watches. More permanent, technical fixes are being instigated by the Energy Coordinating Agency of Philadelphia in a pilot program.

### **Conclusion**

The problem of heat related deaths is not a new one. What is new is the awareness and subsequent level of concern. The news media played an important role in making the public more aware of the dangers of heat. In some cities they are taking on an important role in finding short term strategies. Although more comprehensive strategies combining social and technical change to prevent future deaths and injuries may be the most effective, this would require the involvement of many constituencies who would have to be cajoled and possibly forced into taking positive action.

## **Overview**

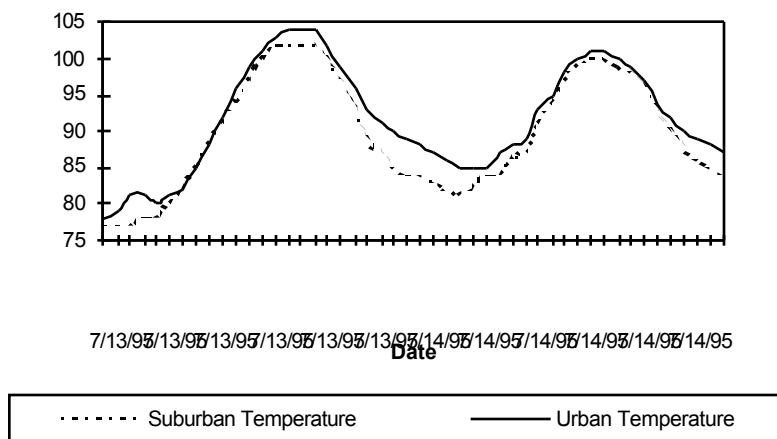
The summer of 1995 brought new understanding to the citizens of Chicago and Milwaukee of the dangers of extreme heat. Accustomed to coping with extreme cold, people found it difficult to manage daily life with temperatures reaching over 100 F. The heat wave resulted in numerous deaths. The Cook County Medical Examiner recorded over 550 heat related deaths (Voelker, 1995). Milwaukee's death toll was proportional to its smaller population, with 91 heat related deaths reported for the month of July. Most of these deaths occurred around July 13-16, the peak of the summer's heat.

Figure 1 shows the difference between temperatures in the urban and suburban areas of Milwaukee. During the 1995 heat wave, the hourly temperatures are consistently higher in the urban area.

One factor increasing city temperatures above those in the surrounding suburbs is the heat island effect. (Voelker, 1995). The heat island occurs due to the heat generating activities of a city. Factories, cars, buildings and the lack of vegetation all contribute. Factories and cars directly add heat into the environment. Buildings absorb heat during the day and release it at night. Over several days of high ambient temperatures and insolation, the building factor may significantly increase the low temperatures at night and have diminished ability to absorb heat during the day.

### **Figure 1**

**Urban and Suburban Temperature Comparison,  
July 13th and 14th 1995**



The coroner or chief medical examiner has the primary responsibility for determining the cause of death. Heat related deaths fall into two categories: when the primary cause of death is heat, normally heat stroke; and when heat is a contributing factor, interacting with or complicating existing conditions. The second category, deaths with heat as a contributing cause, made up most of the Milwaukee and Chicago heat related deaths.

In Chicago, the Chief Medical Examiner used three criteria to determine if a death was heat related. These were:

- the core body temperature was 105 degrees or more
- if temperatures in the house or apartment were over 100 degrees
- decomposition had begun in bodies last seen alive on or around the heat wave's peak.

A Center for Disease Control epidemiologist considered the Chicago diagnoses to be “excellent.” (Voelker, 1995). Voelker, a also found that while individual diagnosis may be difficult to verify as heat-related, the overall estimation of casualties would be fairly accurate. The normal number of deaths vs. the number of deaths occurring during and

around a heat wave allows for a statistical measure of impact. Voelker notes that “heat provides one of the few clearly observable mortality curves in a short amount of time.”

Heat was a primary factor of death in 68 of the 550 Chicago deaths and 34 of the 91 Milwaukee deaths. Psychotropic medication contributed to many of the deaths directly due to heat in both Chicago and Milwaukee. (Borsuk, 1995). These drugs interfere with the heat sensing parts of the brain, preventing the body from making appropriate adjustments. (Semenza, 1995). In Milwaukee 15 of the 91 deaths were people on psychotropic medication, with seven of eight heat stroke victims receiving psychotropic medications. (Borsuk, 1995). Most deaths of those under age 65 were due to this type of medication. The awareness of the dangers of heat due to the use of these drugs has increased, at least within the medical community. For instance, it is now commonly known that many anti-allergy and beta-blocking medications interfere with a person’s ability to sweat. (Geriatrics, 1996).

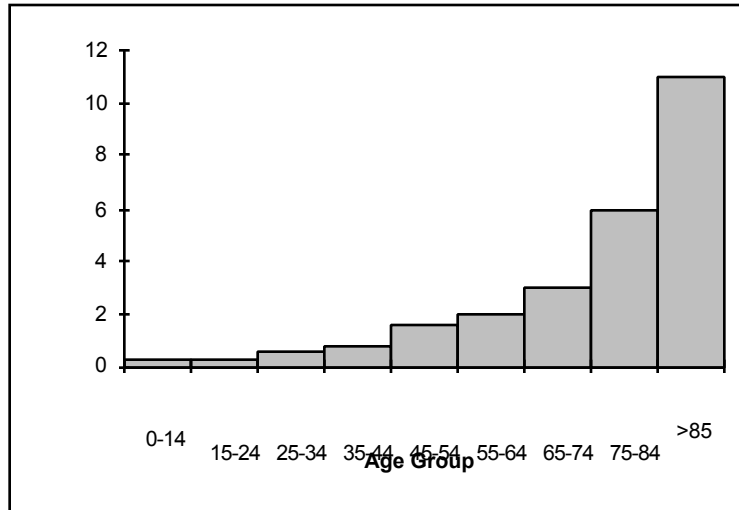
Researchers found several complicating factors in the cases where heat was a contributing cause. Cardiovascular patients were particularly susceptible, as heat strained an already overburdened system. Additionally, many elderly persons have a diminished capacity to detect and respond to increased body heat, as their ability to perceive thirst and/or sweat has diminished. (Geriatrics, 1996).

### **Age and Heat**

Figure 2 illustrates the relationship between heat related deaths and age. The elderly are at the greatest risk, though infants are also in a high risk group. As complications arising from other medical conditions are associated with heat related deaths (especially in the elderly population), efforts to prevent the heat related deaths may have little long term impacts given the existence of a serious medical condition.

**Figure 2**

**Average annual rate of heat related deaths - United States.**



Source: MMWR Vol. 44, No. 25, p.467.

### **Temperature and Death**

Kalkstein and Davis, professors and atmospheric researchers, studied spikes in mortality appearing during times of high heat. The researchers studied the change in all deaths compared against daily temperatures for many locations around the US. A statistically significant difference in deaths during times of these temperature peaks determines the threshold temperature. The threshold temperature for exhibiting these spikes in overall deaths varies from city to city. For Chicago the threshold temperature is about 90 F, with little lag time between the increased heat and increases in the number of deaths.

The authors also note the importance of the timing factor. Heat waves occurring during the early part of the summer have a greater impact than heat waves occurring later in the season. An acclimatization factor may be at work, with people's bodies adapting to warmer weather. Ironically, efforts to keep people cool during heat waves would prevent acclimatization.

Kalkstein and Davis also note that it is not just the temperature high which contributes to an increase in deaths during hot weather. A sustained level of high temperatures existing over several hours has greater impact than extremely sharp temperature peaks which quickly diminish. Thus, a day with many hours above 35 degrees C (95 F) exhibits greater mortality than a day with one or two hours at 40 degrees C (104 F). The longer term stress on the bodies of the elderly, particularly those susceptible to heart attack and stroke is the biggest killer.

### **Observations on the Weather**

The National Weather Service said that the 1995 heat wave was a “highly rare and in some respects, unprecedented event.” (New York Times, 1996, p.A20). However, James Hensen of NASA believes there is a link to global warming and that global temperatures will exceed the 1995 levels. (Schmidt, 1996).

If in fact the NASA consideration of global warming is correct, the frequency of heat waves may increase. However, the global phenomenon does not directly translate into proportional local phenomena. It is virtually impossible to determine how a specific locale would be affected by global warming. If Milwaukee and Chicago experience more frequent heat waves, long term solutions meeting both needs (preventing heat related deaths and global warming) may be the most appropriate measures.

### **Public Responses**

Pictures and stories of the heat related deaths filled the front pages of major newspapers during the July 1995 heat wave. Caught by surprise, politicians vowed to avoid a repeat experience. During the heat wave, cooling stations were the most visible form of public aid. It would appear that the rapid heat increase and relatively short duration made other, more significant responses impractical.

Following the initial July heat, a second heat wave hit the Milwaukee area. Although temperatures only reached into the '90s, the public exhibited greater awareness of the dangers of heat. (Tijerina, 1995). Neighbors tended to check on each other more. However, the public sparsely used two cooling stations and many of the elderly did not want to leave their homes.

The heat related deaths of July 1995 have sparked a new concern over heat waves in northern cities. The shock of unusually high heat affects the elderly the most, with low-income elderly the least likely to have some sort of cooling mechanism, or access to a cool environment. A number of large cities have put plans into effect, with results perhaps as uncertain as the heat itself. This report now turns to the question of who is most at risk. Following is the section on strategies, both current and potential.

## Factors of Risk

Researchers have focused on health and sociological factors when looking for patterns in the 1995 heat-related deaths.. This section discusses health and age factors, reviews existing literature related to the Chicago victims and presents statistical information about the Milwaukee victims.

An analysis of the Milwaukee death certificates reveals several key pieces of information, directing the search for strategies to avoid future heat related deaths. First, deaths tended to cluster in zip codes with lower than average per capita income. Second, of the elderly, those over 80 years of age are disproportionately represented in the deaths. Third, deaths classified as primarily caused by heat affect a much younger population than deaths with heat as a contributing cause. Fourth, there is a one day lag time between the highest heat and the day with most heat related deaths. This suggests that strategies must begin before the heat reaches a peak, demanding proactive response by government and the community.

### Age

A disproportionate number of heat related deaths occurred in the elderly population. Figure X compares the proportion of death in an age group against the percentage of deaths making up the age group's population. One can see that the risk sharply increases for the 80 and over age group.

**Figure X**  
**Comparison Between Heat Related Deaths Among Age Groups Adjusting for the Proportion of Milwaukee County's Population Distribution Across Age Groups**

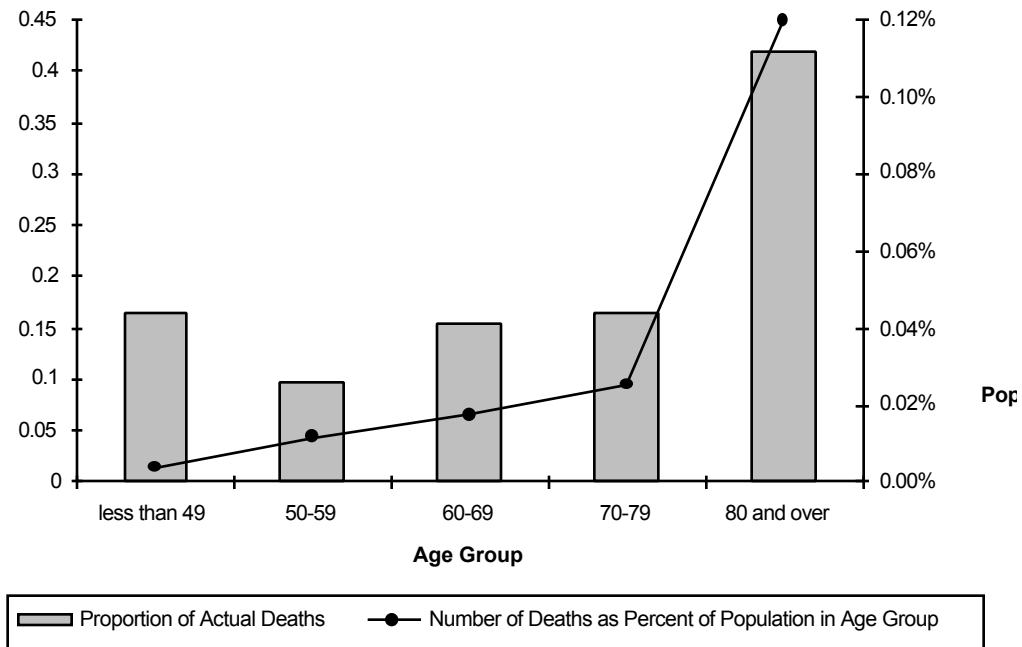
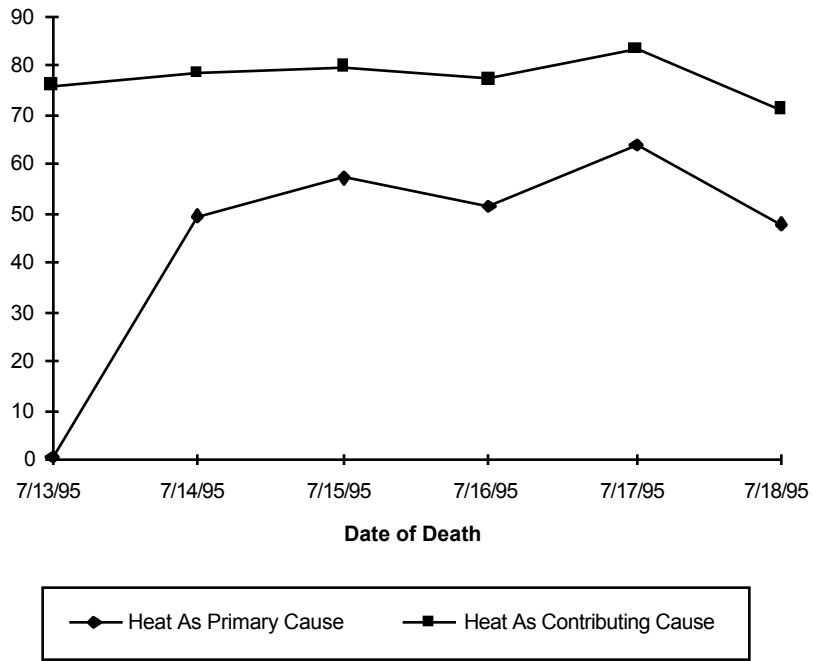


Figure 3 illustrates the relationship between age and the type of heat related death (primary or contributing). Overall, the mean age of those dying from heat as a primary cause was 55, whereas when heat was a contributing cause the mean age of death was 79. Throughout the heat wave and for the few days after, the mean age of deaths retained this relationship.

**Figure 3**  
**Mean Ages of Decedents During the 1995 Heat Wave**

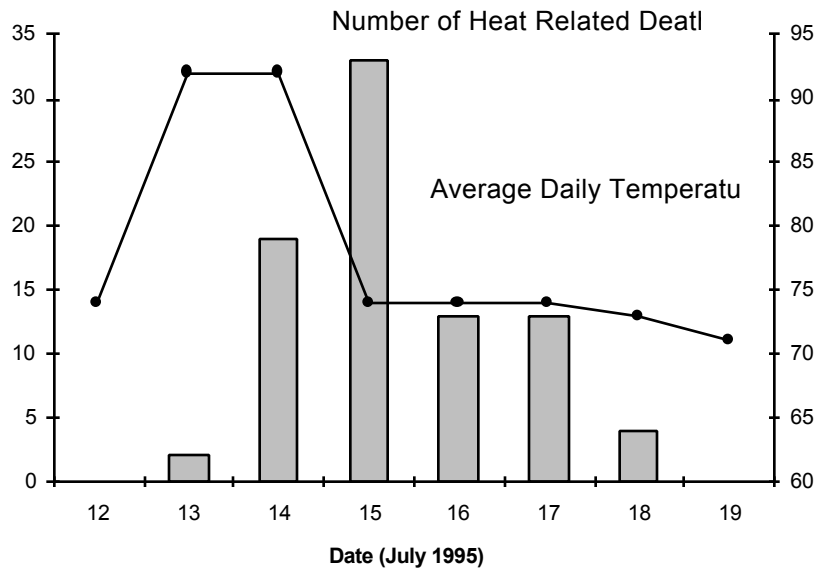


## Heat

Figure 4 illustrates the relationship between the temperature and heat related deaths in Milwaukee. The highest temperatures occurred on the 13<sup>th</sup> and 14<sup>th</sup> of July. There is a lag time of one to several days between the times of high heat and the greatest health dangers. This would reflect on a body's response, similar to an infection. Although the infection does cause immediate harm, the body may cope for several days until the stress is too great to bear, or symptoms manifest themselves.

**Figure 4**

### Temperature and Heat Related Deaths



**Health**

Many of the victims of the heat wave exhibited similar health problems. In the case when heat was a contributing cause those similarities are the primary cause of death. When heat was the primary cause of death, the similarities were the contributing cause. These similarities help to illustrate risk factors of death during times of high heat.

Figure 5 illustrates the primary causes of death in Milwaukee when heat was a contributing factor. Of these 57 deaths, heart disease was far and away the largest contributor. Heart failure, hypertensive cardiovascular disease and obstructive pulmonary disease were also major contributors. These cardiovascular (CV) and cardiopulmonary (CP) deaths represent 52 of the 57 deaths where heat was a contributing cause.

**Figure 5**  
**Primary Causes of Death When Heat Was a Contributing Cause**

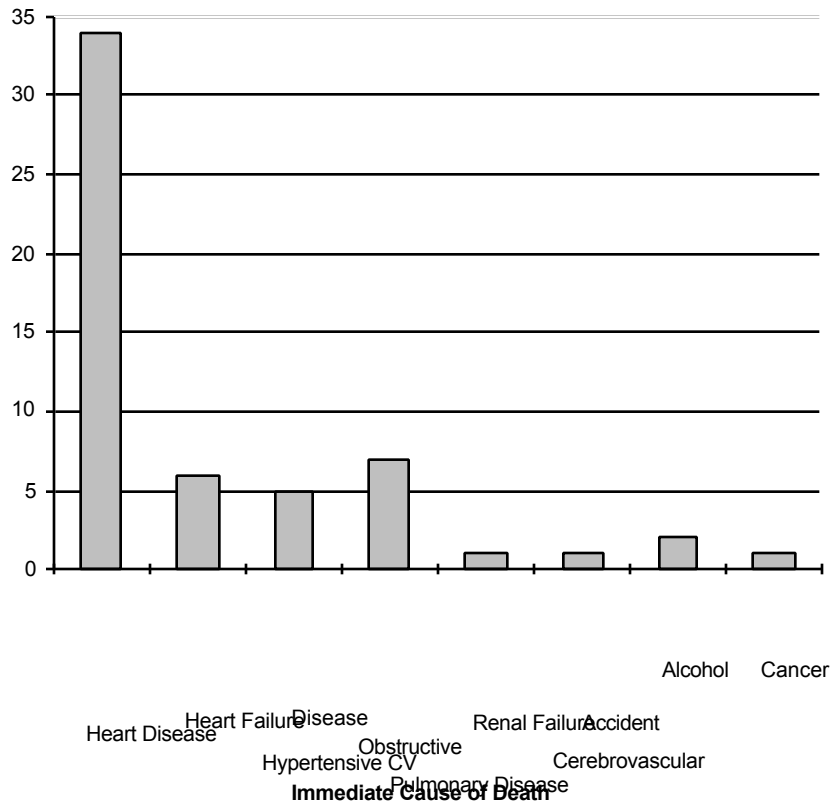
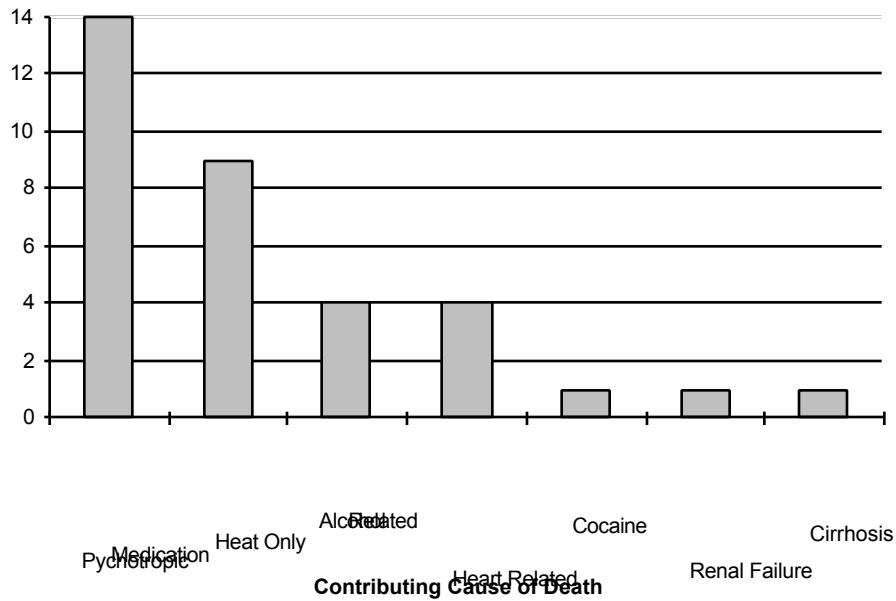


Figure 6XX illustrates the contributing causes of death when heat was the primary cause. Clearly psychotropic medication was the prime culprit, making up 14 of these 34 deaths. The similarity that emerges from these deaths is the contribution of a foreign substance and its effect on a bodies ability to regulate heat. Medication or other foreign substances characterize fully 19 of the 34 deaths (56 percent). Heart related deaths made up only four of these 34 deaths. Heat by itself (no contributing causes) made up only nine of the 34 deaths (26 percent).

**Figure 6**  
**Contributing Causes of Death When Heat was the Primary Cause**



## Findings from Chicago

Jan C. Semenza, a researcher for the Centers for Disease Control and Prevention in Atlanta, along with a team of other public health researchers, conducted a multivariate analysis of factors contributing to heat related deaths in Chicago during the mid-July heat wave. (Semenza, et al. 1995). Semenza interviewed 339 relatives, neighbors or friends of those who died; she also identified and interviewed a similar group of 339 control samples. The researchers made comparisons between those dying of heat, cardiovascular problems or both. This generated odds ratios for a variety of risk factors. Table 1 illustrates some of the findings related to social contacts and living conditions.

A number of observations emerge from this table. The most important factor reducing the risk of a heat related death is having access to air conditioning somewhere (not necessarily at home). Second in importance is social contact.

**Table 1**  
**Risk Factors And Odds Ratios For Heat Related Deaths In Chicago - Social Contacts and Living Conditions**

Variable	Case Subjects (%)	Controls (%)	Odds Ratio (95% CI)
<b>Living Conditions</b>			
Working A/C in home	81 (25)	170 (53)	0.2 (0.2 - 0.4)
A/C in lobby	28 (10)	54 (20)	0.2 (0.1 - 0.5)

Visited cooling shelter	14 (5)	22 (7)	0.5 (0.3 - 1.2)
Visited other A/C	67 (22)	130 (43)	0.3 (0.2 - 0.5)
Lived alone	156 (46)	112 (33)	2.3 (1.3 - 3.5)
Lived on top floor	83 (52)	51 (32)	4.7 (1.7 - 12.8)
<b>Social Contact</b>			
Group activities	140 (46)	167 (55)	0.7 (0.5 - 0.9)
Access to transport	262 (79)	303 (92)	0.4 (0.2 - 0.6)
Friends in Chicago	288 (90)	312 (97)	0.3 (0.1 - 0.6)
Did not leave home (once per week)	75 (27)	19 (7)	6.7 (3.0 - 15.0)

Source: Semenza, et al. (1995), p.87.

### **An Analysis of Milwaukee**

The State's Center for Health Statistics and the Office of the Chief Medical Examiner of Milwaukee

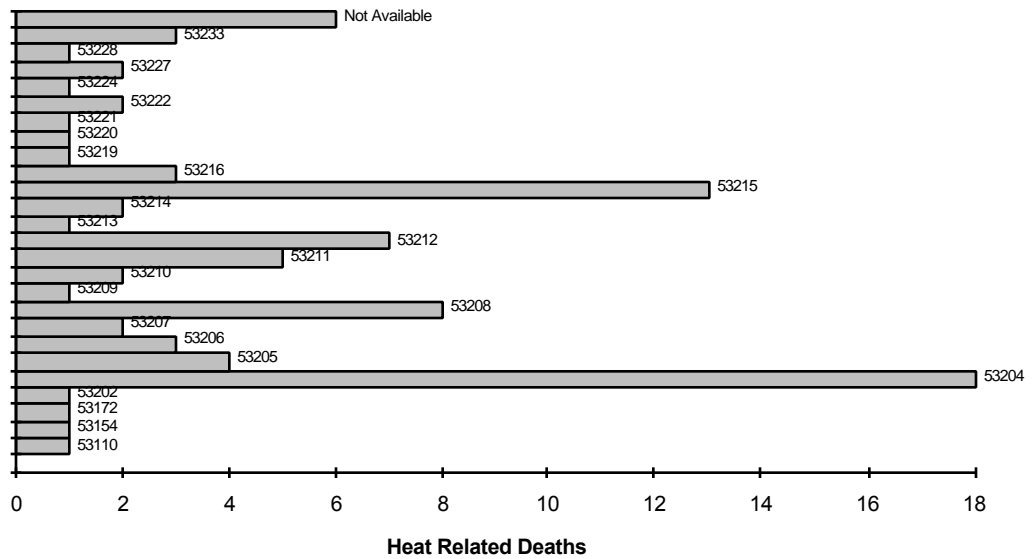
County supplied death certificate information. We used the death certificates to analyze patterns between heat related deaths.

Death certificates include the zip code of decedents. This became the key information around which much of this inquiry revolved.

There appears to be a relationship between place of residence and likelihood of death. Forty three percent of the deaths occurred in three zip codes (53204, 53215 and 53208). These three zip codes are contiguous, with no geographic separation. Note that only twenty-one percent of the deaths occurred in 64 percent of the zip codes. There is a risk factor involved in residing in one of the three zip code areas of 53204, 53215 and 53208. Figure 7 illustrates the number of deaths in each zip code.

### **Figure 7**

### Deaths by Zip Code



### Overview of Demographics

Comparing differences in demographic data between zip code regions allows for a better understanding of the susceptibility to heat of different groups. Zip codes 53204, 53208 and 53215 had 18, 8 and 13 heat related deaths respectively, the highest numbers of heat related deaths among all zip codes. Although these zip codes represent 43 percent of the total heat related deaths in Milwaukee County during the summer of 1995, they make up only 14 percent of the county’s total population. The three zip codes form a contiguous region in downtown Milwaukee.

Table 3 illustrates the varying levels of poverty between the three zip codes and Milwaukee County as a whole. In all cases, greater poverty exists among the three zip codes than in the county. The smallest difference is in zip code 53215. There is a large difference between the number of low-income citizens below the 200 percent poverty level for zip codes 53204 and 53208.

**Table 3**

Income as a Proportion of Federal Poverty Level	Ratio of Poverty to 1989 Income			
	Milwaukee	53204	53208	53215
Under 0.50	6.1%	12.9%	15.2%	5.1%

0.50 to 0.99	5.6%	23.9%	24.8%	11.1%
1.00 to 1.49	7.9%	16.7%	10.9%	10.2%
1.50 to 1.99	8.6%	13.0%	10.8%	11.2%
2.00 and over	67.6%	33.5%	38.2%	62.5%

Source: 1990 U.S. Census, table P121. U.S. Census Bureau web site.

There may be other factors besides income levels influencing the risk of a heat related death. Table 4 illustrates differences between Milwaukee County citizens as a whole and citizens living in the zip codes with the highest numbers of heat-related deaths. These differences help to illustrate how lifestyles and environments vary between areas.

In general, Milwaukee County citizens have a higher per capita income with a lower proportion of people relying on public assistance than the most at risk zip codes. Housing structures are newer in the county as a whole. Interestingly there are proportionally fewer elderly residents in the most at risk zip codes. This runs counter to the observation that the elderly are more at risk, though suggests that the elderly in the most at risk zip codes run an even higher risk of a heat related death than elderly living elsewhere in the county.

Income levels are a measure of the ability of a household to manage heat (through the purchase of an air-conditioner, etc.). Table 4 illustrates that if one is elderly, one is significantly more likely to be living below the poverty level if living in one of the high risk zip codes and therefore less likely to have an air-conditioner. Further, the income similarity between zip code 53215 and the county as a whole disappear when considering only the population over age 65. A percentage of the elderly population is living in poverty for the three zip codes than the county.

**Table 4**  
**Differences Between Milwaukee County and Zip Codes with Greatest Risk**

Indicator	Milwaukee County	53204	53208	53215
Per Capita Income	\$13,383	\$6,697	\$8,225	\$10,842
Percent with Public Assistance Income	11.1%	27.5%	27.1%	11.8%
Percent of Housing with Median Construction Year Prior to 1940	33.0%	73.9%	64.4%	66.9%
Percent of Population Over Age 65	12.6%	8.9%	7.5%	9.8%

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<b>Percent over 65, Below Poverty Level</b>	<b>8.0%</b>	<b>18.3%</b>	<b>13.6%</b>	<b>16.5%</b>
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Source: 1990 U.S. Census, U.S. Bureau of the Census Web Site

A more detailed statistical analysis on the Milwaukee deaths would be useful, but would require more detailed data and sample size larger than 91. Data regarding the victims' income and living conditions would be useful to discover patterns and causal relationships. However, to gather this information would require detailed personal files, not generally available.

The results of the statistics provided in this section show where efforts to mitigate heat related deaths should be targeted. One, low-income areas should be the focus. Two, the elderly in those areas should be especially targeted. With limited resources any concentrated effort would likely see the greatest impact for this group of people.

## **Pollution Impacts<sup>1</sup>**

Heat related deaths for which heat was a contributing cause have similarities based on the primary cause of death. These similarities are problems related to the cardio-vascular and cardio-pulmonary systems. Although heat may be putting the greatest strain on the victims' weakened systems, there may also be other influences which increase the strain, causing more deaths than there otherwise would be with heat alone.

Data from the Department of Natural Resources Air Division reveals that there were extremely high levels of ozone and particulate matter in the air during the 1995 heat wave in Milwaukee. These pollutants put a strain on the cardio-vascular and cardio-pulmonary systems by blocking or otherwise interfering with normal body functions. There is evidence that incidents of stroke also increase around times of high pollution levels. Although air pollution affects everyone in the population, the elderly experience greater impacts, especially those with heart or lung conditions. In many cases, those who died of heat as a primary or contributing cause had cardio-vascular related health problems.<sup>2</sup>

A large body of scientific literature supports this hypothesis. In a study of seven large U.S. cities and the relative risk of congestive heart failure due to pollution levels, ozone levels were positively correlated with temperature. (Morris, 1995). Ponka and Virtanen, researchers at the Helsinki City Center of the Environment, report that pollutants increase the risk of death from CV and cerebrovascular diseases more so than the respiratory causes. In the Helsinki study, they found deaths due to bronchitis, emphysema, tuberculosis, pneumonia and influenza all increased around times of high pollution levels, some by as much as 9.5 times the normal rate (bronchitis and emphysema). (Ponka, 1996, p.1278).

According to a report in Environmental Science and Technology (1996), deaths due to CP failure are related to respiratory stress rather than to the infections themselves. EST also reported that sensitivity increases with age and that toxicity increases when more than one pollutant is present. Citing a study on healthy rats, EST noted that the presence of low levels of ozone and fine particulate matter (2.5 microns or less in size) caused a greater than additive rate of lung cell damage than exposure to the individual pollutants.

In a study of deaths in Los Angeles from 1970 to 1979, researchers used an interesting techniques in the study of daily mortality counts and environmental variables. (Kinney, 1991). Kinney, a researcher with the Department of Environmental Health at the Harvard School of Public Health, had to reduce the correlation between the different environmental factors. This would allow for the extraction of deaths due to specific pollutants. He restricted his analysis to *days with maximum temperatures below 97 degrees F*. In other words, the correlations between temperature related and pollutant related deaths were very high during times of high heat. Additionally, the Los Angeles study found a one day lag time between ozone levels and deaths. The deaths in Milwaukee County occurred primarily on days with maximum temperatures above 100 degrees F, or the following day. Deaths also followed days with high ozone levels.

### **DNR Data Analysis**

The Wisconsin Department of Natural Resources supplied data maintained by the EPA's Aerometric Information Retrieval System (AIRS). Data from June 1 through August 31 1995 was given a cursory analysis to consider the magnitude and timing of high pollution levels.

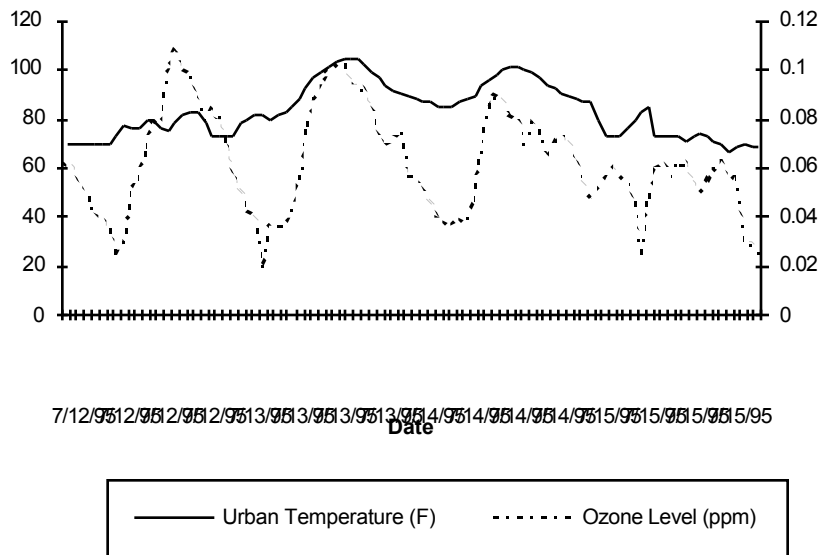
Figure 1 illustrates the temperature and ozone levels at a center city location in Milwaukee (UW-Milwaukee). The ozone level fluctuates between day and night, as

sunlight aids in the development of ozone. On July 13<sup>th</sup>, ozone levels frequently reached the monthly high. Both July 12<sup>th</sup> and 14<sup>th</sup> exhibited extremely high levels of ozone as well.

The DNR also measures particulate pollution levels around the urban city area. Taken every six days, measurements of total suspended particulates (TSP) and PM<sub>10</sub> (particles less than ten microns in size) are indicators of general air quality. Measured in micrograms per cubic meter ( $\mu\text{g}/\text{m}^3$ ), there are several sites around Milwaukee County that measure both TSP and PM<sub>10</sub> levels. Table 1 illustrates the pollution levels of TSP for July 14 and compares them to the monthly and yearly average levels. Table 2 does the same for PM<sub>10</sub> levels.

**Figure**

**Temperature and Ozone Levels  
UWM North Campus  
(Urban, City Center)**



**Table 1**  
**Measures of Total Suspended Particulates (TSP)**

Location (Type)	July 14, 1995 TSP level (ug/m <sup>3</sup> )	Monthly Average (ug/m <sup>3</sup> )	Yearly Average (ug/m <sup>3</sup> )	July 1995 Highest TSP Level (ug/m <sup>3</sup> )
600 E. Greenfield (Urban)	118	57	52	118
2300 S. 51 <sup>st</sup> St. (Urban)	72	40	37	72
3841 W. Wisconsin Ave. (Urban)	112	53	43	112
711 W. Wells St. (Urban)	92	49	45	92

**Table 2**  
**Measures of Particulate Matter Under 10 Microns (PM<sub>10</sub>)**

Location (Type)	July 14, 1995 PM <sub>10</sub> level (ug/m <sup>3</sup> )	Monthly Average (ug/m <sup>3</sup> )	Yearly Average (ug/m <sup>3</sup> )	July 1995 Highest Level (ug/m <sup>3</sup> )
600 E. Greenfield Ave. (Urban)	59	27	27	59
4292 S. 16 <sup>th</sup> St. (Suburban)	46	22	24	46

In all cases the levels of PM<sub>10</sub> and TSP were at the monthly highest level on July 14<sup>th</sup>. In all cases, the levels of particulate pollution are almost twice the monthly and yearly level. One must also consider that the monthly mean is an arithmetic mean, influenced by the

outlying levels. This results in a sharp deviation from the *normal* particulate pollution levels, below the average.

At the UW-Milwaukee monitoring site, located in the central city, pollution patterns may be an indicator of factors influencing the ability of at risk populations to cope with the various environmental stressors. Although temperatures were not extreme on the 12<sup>th</sup>, ozone levels, NO<sub>2</sub> levels and SO<sub>2</sub> levels were all high. This may have begun the strain on cardio-vascular or cardio-pulmonary systems of the elderly or other at risk groups. In and of itself, these pollution levels may not have caused the acute reaction of the following days.

When combined with the high heat of the 13<sup>th</sup> and 14<sup>th</sup>, pollution may play an additive or multiplicative role in causing illness or deaths. First, the high level of pollutants on the 12<sup>th</sup> would have strained the systems of at risk people. The high heat and ozone levels of the 13<sup>th</sup> and 14<sup>th</sup> would increase the strain on their systems, not allowing for the damage of the 12<sup>th</sup> to be healed. In a weakened state, the combined crucibles of the heat wave and high ozone levels may have been too much for many to bear.

## **Strategies**

This cursory review of pollution levels illustrates a need for further research. Pollution monitors recorded high pollution levels in and around the time of the heat wave. This is a confounding factor, extractable with the review of other death statistics, including cardio-pulmonary, cardio-vascular and cerebro-vascular related deaths and injuries.

Assuming that the pollution is a contributing factor in many of the heat related deaths, an expansion of prevention measures targeting at risk populations includes pollution mitigation measures. In some cases these measure may be more cost effective than dealing with solutions to excessive heat.

There are two broad types of solutions to high pollution levels. One can target either an individual's contact with pollution or prevent the pollution from reaching the general population. Each of these have both short and long term impacts, reaching beyond the narrow scope of this study.

Strategies targeting individuals should focus on the most at risk populations. These would generally be similar to the populations who died or were injured during the heat wave. The focus of measures would be to prevent the pollution from entering the lungs. An agency could pass out face masks, on a yearly basis and also make them available during times of extreme environmental pressures, such as the 1995 heat wave or times experiencing high pollution levels. These masks would be quite inexpensive, relative to the cost of an air-conditioner or other physical measures.

This type of policy leaves the remainder of the population inhaling highly polluted air, unless the agency passes masks out to everyone. Additionally, the finer and more deadly particles (PM<sub>10</sub> and smaller) may pass through the filters of the air masks. Assuming that the mask could prevent the acute effects from occurring, it may be appropriate to encourage the population as a whole to use face masks.

Another policy option is one of preventing the ambient pollution levels from occurring, especially during times of extreme temperature. High ozone levels are associated with vehicular traffic. Particulate pollution is increased by stirring up dust, crumbling tires from road wear and industrial activity. Policy would suggest limiting these activities.

By curtailing the activities causing pollution, one would also reduce the heat island effect. The same activities cause both the pollution and the heat island effect. As their negative

effects are linked, so to are the positive benefits by reducing both environmental stressors.

### **Conclusion**

This section of the paper has discussed the possible effects of pollution on heat related deaths and injuries. A brief overview of pollution levels during the 1995 heat wave shows a correlation between the times of extreme heat and pollution levels. Solutions to avoiding future heat related deaths and injuries may also include pollution mitigation measures.

Reducing the ambient pollution levels may have long term social benefits as well as short term death and injury prevention benefits.

## **Strategies for Preventing Heat Related Deaths**

Strategies to prevent future heat related deaths include technological means, social means, or both. They can operate in the short term, such as emergency management or the long term, such as planting trees. Current efforts emphasize emergency management. Taking longer term, more comprehensive measures entails tradeoffs and difficult decision making choices from public officials.

The scale of the problems and strategies varies from the environmental to the individual. Long term efforts entail addressing the heat island effect and building heat gain. Short term efforts utilizing social networks and heat education efforts work for the immediate future. However, this social strategy only effects individuals who have access to a social network or can take action on their awareness of heat dangers. The widespread distribution of air conditioners is expensive, with many considerations reaching beyond the initial distribution. One substitute or compliment, the distribution of fans, may be useful to consider, though the use of fans increases risk during times of extremely high heat. A comprehensive strategy would emphasize social networking for short term management and solid changes in the way society uses energy and constructs and maintains housing units.

### **Technological Mitigation Strategies**

There are four main methods of using or altering technology to reduce the physical heat experienced during heat waves. They are characterized by their scale and application to individual cases. These include measure to reduce the heat island effect of cities, measures to keep buildings cooler, measures to cool rooms and measures to cool individual bodies

## **Reducing the Heat Island**

Successfully reducing the heat island effect could shave several degrees off a day's temperatures and allow greater cooling at night. In this case, one seeks to reduce the amount of heat absorbed by and generated from the city. Measures to reduce the heat island have many benefits, but in some cases would entail temporary societal disruption.

Strategies to reduce the heat island are many. One method is to expand and distribute green areas in the city, increasing the amount of shade and a cooling provided by trees. The second method is to reduce the amount of heat generated by the city itself. The use of cars, air-conditioners, factories and other daily city activities all generate heat. One could reduce this heat by preventing the use of non-essential activities during heat waves. Offices could be closed and transport by car limited. Factories could be shut down. Essential emergency services would be maintained, and retail spaces could be kept open to provide air-conditioned spaces. The declaration of a "heat holiday" could prove to be a popular event, at least for some.

Clearly there are a number of barriers to the successful implementation of these strategies. For many central city areas, expanding green spaces could be difficult, with several confounding hurdles: land value is at a premium, vacant land may be difficult to find and the condemnation of buildings to create green spaces may prove to be politically unpopular. The declaration of a heat holiday may be the most effective method of preventing heat related injury and death and could be implemented fairly rapidly. However, many businesses would be disrupted and many workers may not appreciate losing a day's wages. Although businesses frequently close for national holidays such as the fourth of July, these holidays are planned. A heat holiday would have to be declared on short notice, perhaps only 12 to 24 hours in advance.

## Reducing Building Heat Gain

Buildings gain heat through environmental temperatures (above), internal activities and direct solar gain. Clear skies are the prime promoter of solar gain. Direct sunlight heats building masonry and enters windows. Masonry will take time to cool, increasing the night-time temperature of a dwelling. Windows let in sunlight and the light is turned into heat as it hits interior surfaces. Window glass prevents the heat's escape and dark interior surfaces will absorb the light, soaking in the heat much as building masonry.

Table X is a list of different measures to prevent solar heat gain by buildings. Different measures for different building sizes are based on estimates of costs per application, estimates of the economy of scale of each method and the ability of owners to afford the measure, based on the scale. These technologies are fairly simple, though their installation and effectiveness may be hampered by building designs and conditions.

### Table X

#### Measures to Prevent Building Heat Gain

Structure Type	Heat gain reduction method	
Single Family	Attic radiant barriers	
	Attic ventilation	
	Shade trees	
	Awnings	
	Trellises	
	Outdoor window shades	
	Small multi-family	Attic radiant barriers
		Attic Ventilation
		Shade trees
		Awnings
Large multi-family	Trellises	
	Outdoor window shades	
	Reflective roof coatings	
	Reflective window coatings	
	Reflective roof coatings	
	Reflective window coatings	
	Reflective paint	
Outdoor window shades?		
External Sprinklers?		

One of the biggest problems with the large multi-family (and perhaps the small multi-family) is the large thermal mass. Over an extended hot spell, these buildings can become quite warm. They do not cool much at night when outdoor air temperatures remain warm. With the exception of reflective paint and external sprinklers, all the control strategies are aimed at preventing heat from entering spaces through windows, not structures. External sprinkling systems will require large amounts of water, could cause damage and is likely less effective in humid weather. More research into preventing heat gain by the structure is necessary.

### **Cooling Interior Spaces**

Third level of scale is inside a building. During a heat wave unconditioned areas can become quite hot, especially if the building has experienced large amounts of heat gain. Strategies to manage heat in living areas include cooling the air, the use of fans and avoiding heat generation. The large scale distribution and use of air conditioners may be difficult for reasons described below. Avoiding interior heat generation is largely a matter of education (i.e. don't prepare hot meals on hot days).

Air conditioners are a basic and well understood technology. They are simple to operate and generally reliable. However, for many elderly on fixed incomes, the first cost of the air-conditioner can be prohibitive. Even if the air conditioner could be given away, people may be unwilling to use it due to the high operating cost. Many of the elderly will avoid risking bill arrearage at the electric utility, despite obvious health risks. Additionally, on hot sweltering days an electric utility's pleas to conserve energy and reduce the peak demand are at clear odds with the need for air conditioning, creating confusing messages for the public. Even in Philadelphia, where PECO defers utility shut-offs during a heat

wave, there are no means of getting people reconnected prior to or during a heat wave. Secondly, after the heat wave, people are removed from the system due to non-payment, making them vulnerable to a second heat wave.

One could also use an existing refrigerator as part of a cooling mechanism. Making ice and placing ice in an air distribution system, such as the Celsius (a patented technology using an ice tray on top of a box with a fan which brings in hot air over the ice and distributes cool air to the room) is another option, though still in the price range of an air conditioner. The main operating costs would come from the increased use of a refrigerator to make ice. The only savings to the customer come from first cost savings by not purchasing another refrigeration unit. Increased electricity bills would be effectively masked by rolling them into the existing cost of refrigeration.

At the state or local level, some guarantee that electricity will be available must be developed for an air conditioner strategy to succeed. Typically, utility customers with life maintaining medical equipment in their homes can notify their utility in order to prevent a disconnection. In the case of the air conditioner, this could be justified as a medical device for at risk populations. People with the “medically justifiable” air conditioner would be protected from utility shut-offs.

Fans are used to either generate evaporative or convective cooling for an individual or to ventilate a room. When temperatures are below 100 F, fans can help cool a body. However, when temperatures are over 100 F the fans can be dangerous and actually increase the heat transfer to the body. This is especially the case in humid weather when evaporation becomes difficult. The fan effectively acts as a convective oven. During the evening hours, fans can be used to remove hot air from a room. The cooler night air is brought in, bringing the average temperature down. This is an important consideration as it is the longer term exposure to high heat (1 to 2 days) which puts people most at risk.

### **Cooling the Person**

Each of the above three cooling methods has involved making the air around a body cooler than it would otherwise be. However, the primary concern is to keep a body cool, not the air. Technology for cooling a body may prove effective and be readily available. New technologies could also be developed.

Existing technology to cool a body exists in many homes. It has been suggested that cool showers or baths can provide the necessary cooling required by a body. Unfortunately, for many of the elderly this option may prove dangerous if unattended or impossible if facilities are unavailable.

Another option is to develop a new cooling technology or adapt existing ones. One idea is to develop clothes for cooling an individual. A shirt with pockets for holding ice or cold water could be easily designed. Plastic cases containing “blue ice” or similar material could be chilled in a freezer and put into the pockets of the shirt, strategically placed. The central core body would be kept cool.

### **Existing Strategies in Milwaukee and Philadelphia**

Both Milwaukee and Philadelphia have taken measures to reduce the number of heat related deaths. Philadelphia’s approach is decentralized and uses an existing social network. Milwaukee’s approach is more centralized and has attempted to create new social networks. In both cases there is an emphasis on short term emergency management, with little discussion of long term strategies. One organization, the Energy Coordinating Agency of Philadelphia, is taking small steps towards a more comprehensive, long term approach.

### **Milwaukee**

Previous concern over heat waves led to the development of a Heat Task Force, in existence since 1986. (NOAA, 1995). It wasn't until nine years later that the need for the Task Force became apparent. Although the Task Force received accurate weather forecasts up to five days in advance, they did not meet until July 14, the middle of the heat wave. The extreme medical situation did not begin to manifest until that time. Just as the general public, the Task Force was not used to dealing with the excessive heat. Efforts to mitigate the effects of the heat, such as expanding cooling shelters began at that point.

In response to the 1995 heat wave, many organizations came together to address the concerns raised by the harrowing spell of extreme heat. The City Milwaukee Health Department, Police Department, Fire Department, Medical Examiner, National Weather Service, Salvation Army, Wisconsin Electric Power, Social Development Commission and the Milwaukee County Adult Services Division are just some of the many organizations which banded together. The organizations realized that while each had an interest in solving heat induced medical problems; separately they could do very little to address a community wide problem, while together they could draw on each other's strengths.

In order to prevent a similar situation, speed up the response time and improve the responses, the organizations making up the Task Force met to identify problems and coordinate solutions. Five issues were identified for the Task Force to tackle: 1) planning efforts, 2) public education, 3) aiding high risk groups, 4) access to cool areas, 5) emergency planning. The Task Force developed solutions drawing on the strengths of each organization.

In general, the Task Force's plans emphasize managing an emergency situation, rather than long term preventative efforts. This plan is reviewed and updated each spring by the Task Force. Heat waves are viewed as a medical concern by the Task Force, rather than socioeconomic. As a result, the City of Milwaukee Health Department is the hub around which much of the efforts rotate.

The Health Department facilitates planning with annual meetings held each spring. In order to address the above five issues, the agencies automatically take on their different roles based on weather forecasts and warnings issued by the Health Department. The Health Department coordinates efforts by the issuing Heat Health Action Notices. A Heat Health Action Notice has four levels, with increasing concern and effort towards meeting the needs of Milwaukee's citizens. The communication aspects of planning for the heat are characterized by monitoring emergency rooms, notifying the mass media, operating a hot line and possibly increasing the level of the Action Notice to bring efforts on-line.

The Health Department emphasizes its efforts to educate the public as a whole during the spring. There are several levels the Health Department's efforts. . The use of the "Heat Index" on local weather reports is meant to become as commonly understood as the wind chill factor of the winter months. The Salvation Army, Frail Elderly Registry and the County Department on Aging/Interfaith maintain lists of their clients. An effort is being made to make those lists more generally known to facilitate hot weather check-ins of elderly or other at risk people. Making the most at risk people more commonly known to the community as a whole offers the opportunity to 1) get more people on the lists and 2) encourage people to check on their elderly family members or friends. The Health Department also uses education efforts to aid the public in learning about the dangers of high heat index days and how to properly respond to different levels of Heat Health Action Notices.

The Task Force has designed four tiers of warning, corresponding to the risk of a heat wave and heat related injury and death. These tiers define particular actions which should be taken by the Task Force and particular agencies. The issuance of these Heat Health Action Notices comes from the Milwaukee's Health Department. The four tiers are shown in Table X.

In order to aid at risk groups, the Task Force is conducting efforts to identify, reach out to, educate and assist high risk populations. The Task Force has identified the high risk populations as the:

- Elderly,
- Physically disabled persons,
- Chronically ill people with cardio-vascular,  
cardio-pulmonary or metabolic problems,
- Patients possibly taking psychotropic medication,
- Cognitively disabled persons
- Infants
- Obese people
- People with difficulty understanding english, the illiterate or otherwise  
communication impaired,
- People whose activities would place them at risk (such as athletes or construction  
workers).

Table X

Warning Level	Milwaukee's Heat Warning System and Task Force Action Plan Condition for Issuance	Task Force Action
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Heat Outlook	High temperatures are expected in 48-96 hours	The task force reviews its plans
Heat Watch	High temperatures are expected in 12-48 hours	<ol style="list-style-type: none"> <li>1) Hospitals are surveyed for heat illnesses</li> <li>2) The health department initiates a 24 hour response to calls related to heat</li> <li>3) A mass media heat health watch is issued.</li> <li>4) A notice that a heat advisory status will be issued in 12 to 48 hours is issued</li> </ol>
Heat Advisory	<ol style="list-style-type: none"> <li>1) When one case of a heat-related illness is reported from a residential setting or one report of heat stroke is reported from outdoor work or recreational settings <b>or</b>;</li> <li>2) When the short-term forecast for heat has a heat index greater than 105 degrees during the day and greater than 80 degrees at night.</li> </ol>	<ol style="list-style-type: none"> <li>1) Cooling sites are opened if demand warrants</li> <li>2) A daily check on high risk people is initiated</li> <li>3) Home cooling assistance is provided for on an emergency status.</li> </ol>
Extreme Heat Warning	<ol style="list-style-type: none"> <li>1) Issued when there is more than one case of a heat related illness reported from residential areas or multiple reports of heat stroke are found in recreational or outdoor work sites <b>or</b>;</li> <li>2) Issued when the heat index must exceed 115 for more than 3 hours of the day and the air temperature exceeds 80 degrees at night</li> </ol>	<ol style="list-style-type: none"> <li>1) State agencies are alerted</li> <li>2) Consideration is given to extending cooling site hours.</li> <li>3) Consideration is given to a multi-agency command center.</li> </ol>

Source: City of Milwaukee Health Department, 1997.

This list begins to cover a large segment of the population and captures those who are at risk for both dying from heat and being injured by the heat. The Task force also includes other factors which further increases the risk of the above at risk populations. These are:  
 People with limited capabilities to change or respond to environmental stresses (low-income, high crime areas or physical dependence on others),  
 Those living on the upper floors of non-air-conditioned buildings,

Social isolation  
Neighborhoods with a greater heat island effect.

In order to identify the most at risk population in the most at risk areas, the Task Force encourages those who serve these populations to enroll their clients in check in services. As part of the Heat Health Action Notices, people will be reminded by the media to check on their at risk clients, friends and family members.

The physical cooling need may be the most critical aspect of the overall program noted by the Task Force. It does little good to know you or someone else is dangerously warm if no avenue exists to relieve the heat. The Milwaukee Health Department will distribute information to agencies and the general public regarding cooling facilities and air conditioned areas. When it is not possible for an individual to make it to a cool area, hospitals, medical personnel and government agencies will assess the individual's risk and need, responding accordingly.

In general, the Task Force has been able to coordinate efforts between public and private organization. However, the efforts focus on responding to emergencies, not preventative measures. There has been only two summers since the 1995 heat wave. A similar heat wave may not arise for several years or even decades. As the Task Force designed the plans to generate action based on an emergency situation, there is a chance that the institutional memory of their importance or reason for existence will become dulled. Although the yearly spring meetings should help to prevent this at a coordination level, the general public is not reminded or updated. Long term preventative measures may be required to instill a culture of "heat respect" into the mind of the public. The use of the local media may prove to be a crucial means to maintain the public's awareness. The use of the heat index and explanations of its meaning will help to instill some level of

understanding. Slow news days during the spring and summer may prove to be good times to emphasize the dangers of heat.

During the summer of 1996, these efforts were put to the test. Temperatures in Milwaukee reached into the 90's, providing the opportunity for issuing a heat advisory. (Kissinger, 1996). An overall 33% increase in ambulance calls were related to heat. One ambulatory service reported that 80% of its 150 calls were heat related. Heat related deaths did not appear to be a problem. The 24 hour hot line was used extensively by the public.

The plan did overcome one key aspect of miscommunication that may have lead to the slow response during the 1995 heat wave. By having the coroner aware of hospital admittances and the hospitals aware of the coroner's types of death, the medical community was able to see a pattern before services were overwhelmed. This information is provided to the City's Health Department to aid in Task Force coordination. In the case of the summer of 1996, the need for intensive measures did not arrive. Had there been a greater threat to public health, agencies tied to the network would have been notified and advised to implement their heat emergency plans.

### **Philadelphia**

In 1993, Philadelphia experienced a situation similar to Chicago and Milwaukee., Unusually high heat lead to 118 deaths. The city dealt with the situation in comprehensive manner, finding solutions which cover many aspects of a heat emergency. First, Medical Examiner expanded his criteria for diagnosing a death as heat related. Second, climatologists developed a new forecasting method to more accurately gauge the health risk of weather. Finally, the strategy uses Philadelphia's cultural attributes to more effectively meet the needs of at risk populations.

Pivotal to Philadelphia's approach is its decentralized nature. The City's citizens are relied on to check in on their neighbors. In a city of 1.6 million, a centralized approach would be impractical, likely leaving many gaps. Philadelphia's Health Department acts as a coordinator of information, though actual measures are left to others. The City is attempting to develop a culture which encourages citizens to look in on one another, and simply be aware of the dangers heat can pose to the vulnerable.

The medical examiner in Philadelphia felt that the traditional method of categorizing a death as heat related or not was too restrictive and resulted in an undercount of heat related deaths. The problem was that many deaths are not discovered for several days. The body and environmental temperatures have had a chance to cool off. To correct the problem, three factors are used to categorize a death as heat related. It can be based on core body temperature, environmental temperatures where the body was found or the state of decomposition of a person's body, last seen alive around the time of the heat wave. This method was used by the Chicago and Milwaukee coroners in 1995.

Climatologists have developed new methods of weather analysis, known as synoptic forecasting. (Libby, 1997). Dr. Kalkstein of the University of Delaware has studied the effects of weather on mortality. He has found that certain oppressive air masses exist which increase the mortality of cities. There is no common, "deadly," air mass. Rather, it is suspected that different cities have their own particular characteristics which help to make a particular air mass more deadly than another. Essentially, Dr. Kalkstein considers more weather variables than just heat and humidity. He also considers such factors as wind speed, wind direction and air pressure. The mortality statistics for a city are compared against the overall weather pattern for a number of years. This allows for a prediction of the number of deaths for a given forecast.

Philadelphia has adopted this type of forecast to better respond to weather emergencies, especially in the summer. (NOAA, 1995). Three levels of heat warning are issued by the Heat Health Commissioner. A Health Watch occurs two days prior to an expected dangerous air mass. One day before the arrival of the air mass a Health Alert is issued. Just before the dangerous air arrives, a Health Warning is issued with its own three levels of concern. The type of Health Warning issued is based on the number of deaths predicted by the model. These warnings are issued in conjunction with Heat Warnings from the National Weather Service, when heat index values are expected to reach 105 degrees for three hours or more on two consecutive days.

The success of the new forecasting system is not clear at this time. The 1995 heat wave in Philadelphia saw the issuance of warnings suggested by both the Kalkstein and NWS methods. During that hot spell the Kalkstein method over predicted the number of weather related deaths. Most deaths occurred during times when no warnings were broadcast. As the statistical measure is based on an average past history, a specific moment in time is not an appropriate time frame to judge the system. It may take several applications of the system before some measure of success or failure can be recognized. Further, the goal of warnings is to reduce the number of deaths through the implementation of preventative measures. Thus the statistics are existing in an ever changing system, making inference difficult at best.

In a response to the heat related deaths, the Energy Coordinating Agency of Philadelphia (ECA) developed a pilot program to address the problem. The ECA is a city wide non-profit agency which aids their low-income clients in energy related problems. Through a grant from the Pew Charitable Trusts the pilot program formed a volunteer effort to identify, educate and aid at risk people.

The Home Energy Safety program helps at risk populations deal with extreme weather conditions, both hot and cold. The program operates once each six months, during daylight savings time. The local health department, fire departments, television stations and aging agency conduct outreach efforts with the ECA. Citizens are informed about weather related problems; the upcoming heat during the spring and soon to arrive cold during the fall.

Part of the ECA is its Neighborhood Energy Centers (NECs). Five of these centers are sprinkled around Philadelphia and provide a local base for helping citizens with their energy concerns. The semi-annual Home Energy Safety program “front line” volunteers spread from these centers to aid the local area. Volunteers are separated into teams, with each volunteer is given an identification badge and tee-shirt along with enough basic supplies to serve two households. The volunteers carried caulk, smoke detectors, batteries, furnace filters and other basic maintenance tools. The ECA accompanies the teams with staff experienced in home plumbing, heating and electrical maintenance. When appropriate, the clients are referred to other programs which may help them meet their needs (such as weatherization or housing rehabilitation services).

Clients served by the volunteer efforts are identified from the Neighborhood Energy Center client lists, and are made up of disabled and elderly individuals. There is an effort to focus on isolated people. These lists are not exhaustive in counting all at risk people, with the most isolated still missed. Conditional on the expansion of the program, the ECA may begin to use utility shut-off lists to help identify at risk people. Additionally, the use of volunteers limits who to serve. For safety reasons some homes are passed by.

This pilot program has been in place for two years. During the Spring of 1996, the ECA had 44 volunteers participate in the program. Fifty senior citizens were served with

window fans and screens, smoke detectors, carbon monoxide detectors and educational packets. These ECA and the NEC efforts are focussed on prevention efforts as opposed to emergency efforts. During the summers, the NECs distribute fans, with instructions as to their proper use. During the summer of 1996, the NECs distributed 75 fans in Philadelphia.

Another notable part of Philadelphia's cultural response is the use of volunteer organizations. The heart of the plan is the use of a "block captain." Each block in Philadelphia is a part of the Philadelphia More Beautiful Committee. This organization spruces up and maintains city blocks to give a more pleasing appearance to the city and is a volunteer organization. Because each block has a block captain as part of the organization, this organization is spread throughout the city. During times of high heat the Health Department in Philadelphia sends letters to each block captain requesting that they check on elderly members of the neighborhood. These captains may or may not do so, as they are volunteers.

Other cities can learn from Philadelphia's experience, but direct application may not be appropriate. The block captains of Philadelphia are a local cultural phenomenon. Other cities may or may not have a dedicated, ubiquitous organization. Indeed, Milwaukee uses a number of social organization networks, using their city's unique cultural map. The essential key of Philadelphia's efforts is wide spread public awareness. Heat warnings begin two days prior to forecasted hot weather. This enables those organizations to understand and respond to the dangers of heat waves in a more proactive rather than reactive manner.

Philadelphia's system is decentralized. Indeed, it would be virtually impossible and extremely costly for a city government or even city agencies to check on all its senior

citizens. Although the Milwaukee plan is similar to Philadelphia's, the heavy reliance on "check-in" lists will likely leave many people behind. In Milwaukee less emphasis is placed on diffuse, neighborhood based efforts. In Philadelphia, the general public is empowered to help, with concern and understanding nurtured by the government.

### **Barriers to Strategies**

Both social and technological strategies have barriers to implementation and operation. In general, social measures can cast a wide net at low cost, but rely on the participation of society at large. Technological measures can effectively reduce risk for anyone receiving the measure, but require a detailed "top-down" approach for widespread monitoring and resource leveraging.

Social organization is the focus of most major efforts to address heat related deaths. Philadelphia and Milwaukee have implemented plans which emphasize education, heat warnings and voluntary check-ins of at risk populations. There is little monitoring, so the effectiveness of these plans is unknown. In Philadelphia, their new weather system predicted 163 heat related deaths during the summer of 1995. "Only" 70 people died from the heat wave. Either the social networking was successful or the computer modeling missed the mark (maybe a bit of both).

There are also barriers to the success of the social network strategy. The time lapse between heat waves may be decades in length. The institutional memory may be forgotten or dulled as older public officials and administrators leave and new ones come on board. The ineffectiveness in 1995 of the Milwaukee Heat Task Force (developed in 1986) illustrates this problem. The general public and news media may lose interest after several years since the last heat wave.

To fundamentally address the issue of heat related deaths, action at all technological levels may be required in conjunction with social networking. However, given scarce resources, a smaller selection from the menu is more realistic. The initial efforts made by Milwaukee and Philadelphia represent the first step. They cast a wide net and attempt to get everyone involved.

The problem of heat related deaths will not go away. Unless concrete measures are taken at the social level, with technological means filling in the gaps, it is unlikely that heat related deaths will decline. The specter of global warming looms and threatens to increase the number of heat waves. Measures addressing heat related deaths have many positive spin-off effects, far beyond the reduction in the deaths.

## **Future Research Needs**

The needs for further research are many. They cover topics as disparate as demographics to weather and pollution interactions to technological fixes . In many cases the required information, such as personal demographic data, may be difficult to obtain. In other cases the information may not exist or be incomplete, such as pollution levels or their effects.

### **Demographic Information:**

One hindrance of an improved statistical analysis is the lack of full demographic information related to the specific heat related death cases. A more detailed and meaningful analysis would require that specific income levels, types of residence and social contacts be available.

The second demographic need is more specific information about health conditions. A health comparison between heat victims and non-victims would be useful. If most heat related death victims had progressed far into their respective diseases, measures to provide cooling may have very little long term benefit. This might be the case for those with severe cardiovascular or cardiopulmonary problems. However, other types of health problems may not fit this pattern, so indeed, cooling measures would have a stronger impact in terms of improving life for heat sensitive patients.

Specifics regarding the living conditions of heat death victims is also needed. The use of aggregate data hides the individual situation which may have lead to the death.

### **Housing Information**

Determining specific residential characteristics may require on site visits to the neighborhoods and residences of all heat related death victims. The condition and type of

the building, and perhaps specific living quarters is needed to render a solid judgement on the impact of housing structures on heat related deaths.

Discovering the “truth” about the impact of different housing conditions is important when considering what physical measures to take. Additionally, funding methods would also be dependent on housing ownership. If deaths only occurred in large apartments, efforts targeted at landlords would result in a different program than one targeted at single family dwellings.

### **Pollution Information**

It is exceedingly difficult to diagnose a specific death as pollution related. In all the studies of human populations, the method of determining the number of pollution related deaths was based on discovering the correlation between the number of deaths and different pollutants. Further research should also be made into considering the combined impacts of heat and pollution.

### **Strategy Research Needs**

The history of finding solutions to heat related deaths and illness is a short one. There is little experience in experimenting with either societal or technological solutions, at least in a Midwestern climate. An interested agency should track the effectiveness of different measures.

On the technical side, research should consider several factors. The buildings which contained heat death victims should be studied for their heat gain problems, with specific recommendations made for particular building types. Medical equipment should be developed that cools either the air around a body (air-conditioner) or a body itself.

The existing solutions as implemented by the major cities experiencing large numbers of heat related deaths should be studied. The relative success or failure of each should be compared. Networks developed by each city can be compared for how they use their existing cultural attributes. Similarities can be drawn out to judge the relative comprehensiveness and practicality of each network concept.

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<sup>1</sup> Descriptions of pollutant properties and sampling can be found in the Wisconsin 1994 Air Quality Report, State of Wisconsin Department of Natural Resources Bureau of Air Management. Information regarding pollutant impacts comes from this document.

<sup>2</sup> Semenza, 1995.