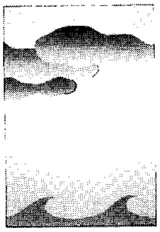
The Philadelphia Hot Weather–Health Watch/Warning System: Development and Application, Summer 1995



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ABSTRACT

Last summer, Philadelphia, Pennsylvania, instituted a new Hot Weather–Health Watch/Warning System (PWWS) to alert the city's residents of potentially oppressive weather situations that could negatively affect health. In addition, the system was used by the Philadelphia Department of Public Health for guidance in the implementation of mitigation procedures during dangerous weather. The system is based on a synoptic climatological procedure that identifies "oppressive" air masses historically associated with increased human mortality. Airmass occurrence can be predicted up to 48 h in advance with use of model output statistics guidance forecast data. The development and statistical basis of the system are discussed, and an analysis of the procedure's ability to forecast weather situations associated with elevated mortality counts is presented. The PWWS, through greater public awareness of excessive heat conditions, may have played an important role in reducing Philadelphia's total heat-related deaths during the summer of 1995.

1. Introduction

Interest in the impact of weather on human health has increased dramatically in recent years, especially in light of potential climate changes (IPCC 1995; WHO/WMO/UNEP 1996). There is well-documented evidence that hot weather, in particular, contributes to increased morbidity and mortality in large urban areas (Pennsylvania Emergency Management Council 1994), and numerous cities have established watch/warning systems to help the local health departments prepare for dangerous conditions. Most of the systems in place are based on a series of National Weather Service (NWS) guidelines and rely on the computation of the "heat index" (also known as apparent temperature), which combines the impact of temperature and relative humidity (NOAA 1994). Specifically, an excessive heat warning is issued by the NWS when daytime heat index values are expected to reach 40.5°C (105°F) or above for more than 3 h a day for 2 consecutive days, or when the daytime heat index is expected to exceed 46°C (115°F) for any length of time.

Watch/warning systems based on the heat index are deficient for a number of reasons. First, they assume that people respond to a combination of only two meteorological variables: temperature and relative humidity. It is quite clear from other studies that a number of other meteorological variables play a significant role. For example, cloud cover has been shown to be a statistically significant predictor of elevated human mortality during hot weather, as clear skies add considerably to the heat load of dwellings, especially those in impoverished urban areas (Kalkstein and Davis 1989). In addition, wind speed is a desiccating factor and adds heat load to the body when temperatures are excessive (Steadman 1979). Second, the present NWS system does not take into

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In final form 26 February 1996.
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account the negative impact of several consecutive days of oppressive weather (no changes are made beyond 2 consecutive days), nor does it account for the fact that heat waves earlier in the summer season seem to create more of a health danger than those late in the season (Kalkstein 1993; WHO/WMO/UNEP 1996). Third, the heat index values used to define dangerous conditions have not been proven as estimators of either morbidity or mortality. Fourth, no estimates of morbidity or mortality can be derived from excessive heat warnings, as there is no empirical basis for the establishment of criteria. Finally, these same values are used at numerous locations without regard to human adaptation or acclimatization; a heat index of 40.5°C will have a much different impact on the population in Boston than in Dallas (Kalkstein and Valimont 1986).

Persons respond to the total effect of all weather variables interacting simultaneously on the body, rather than to individual meteorological elements. Therefore, an appropriate means to evaluate weather–health relationships is through the identification of high-risk or "oppressive" *air masses* that, when present, could negatively impact human health. Studies funded by the U.S. Environmental Protection Agency (EPA) and the Southern Regional Climate Center indicate very strong relationships between particular excessively hot, oppressive air masses and increased human mortality (Scheraga and Sussman 1996). Based on results from these and other studies, the Philadelphia Hot Weather–Health Watch/Warning System (PWWS) was developed. Through the identification of such oppressive air masses, the PWWS provides information to the public and appropriate health agencies that weather situations that could be potentially hazardous are predicted or imminent.

A direct association has been noted between oppressively hot weather and increased human mortality in a number of studies (Smith and Tirpak 1989; Kalkstein 1993; Kunst et al. 1993; Touloumi et al. 1994). In particular, mortality increases sharply above specific weather thresholds, especially maximum temperature, in many domestic and international cities (Kalkstein and Davis 1989; IPCC 1995). Through the use of a synoptic climatological approach, Kalkstein (1991) found that one particular summer air mass in St. Louis possessed the highest mean mortality and occurred on many of the highest mortality days, even though it was climatologically infrequent. Although not all days within this air mass possessed high mortality totals, it was possible to determine which meteorological (e.g., temperature, cloud cover) and nonmeteorological (e.g., consecutive day sequence, within-season timing of occurrence) parameters were associated with the highest daily mortality totals.

City location, the magnitude of the urban heat island effect, and housing conditions influence the magnitude of the negative health impacts associated with oppressive summer weather. Cities in the northeastern and midwestern United States demonstrate the strongest weather–mortality relationships, and this may be due in part to the irregularity of oppressive summer air masses. Such situations occur much more frequently in the southeastern United States, permitting behavioral and possibly physiological acclimatization to these conditions. Housing type, especially in the inner cities, may also play a role. In cities such as Philadelphia and St. Louis, the prevalence of multifamily structures characterized by red brick walls, tar roofs, and poor air flow contributes to inferior ventilation and increased solar load on the building when compared to similar inner-city housing in the Southeast and the West. It is easy to understand why the number of heat-related deaths in a city such as Chicago can top 500 in a few days during an intense heat wave (Kalkstein 1995). Thus, it is these cities that require the establishment of a comprehensive weather–health watch/warning system, to permit city health departments to take mitigating action and to alert the public that dangerous weather is predicted.

2. Development of the watch/warning system

a. Meteorological data and synoptic category development

An automated airmass-based climatological index was developed for the PWWS to categorize each day based on its meteorological character using a synoptic climatological approach. The synoptic procedure has been designed to group days that are meteorologically homogeneous. This is accomplished by defining each day in terms of six readily available meteorological elements (air temperature, dewpoint temperature, total cloud cover, sea level pressure, wind speed, and wind direction). The elements are measured four times daily (0100, 0700, 1300, and 1900 LST), and the developed 24 variables represent the basis for categorization.

The PWWS is based on the temporal synoptic index (TSI) (Kalkstein et al. 1987), which uses principal components analysis (PCA), a technique that rewrites the original 24-variable data matrix into a new set of components that are linearly independent and ordered by the amount of the variance they explain (Daultrey 1976). *Component loadings* are calculated, which express the correlation between the original variables and the newly formed components. Each day is then expressed by its particular set of *component scores,* which are weighted summed values whose magnitudes are dependent on the weather observation for each day and the principal component loading. Thus, days with similar meteorological conditions will tend to exhibit proximate component scores. Refer to Kalkstein et al. (1987) for a detailed discussion of PCA in the development of the TSI.

A clustering procedure is then used to group those days with similar component scores into meteorologically homogeneous groups, which represent the airmass types. There are numerous clustering methods available, but previous studies have shown that an efficient clustering procedure in the development of a synoptic climatological index is the average linkage method (Kalkstein et al. 1987; Yarnal 1993). Once the groups have been determined, average meteorological characteristics are determined for the 24 meteorological variables for all days within each particular group (air mass). Weather map evaluation is also performed to describe the general characteristics and similarities of each TSI group (Table 1).

b. Mortality data

The National Center for Health Statistics (NCHS) produces a detailed mortality database that contains a record for every person who died in the United States from 1964 to the present. The data include cause, place and date of death, age, and race (NCHS 1978). These values were extracted for the Philadelphia Standard Metropolitan Statistical Area (SMSA) from 1964–66, 1973–76, 1978, and 1980–88, years for which the date of death is included. A tabulation of total deaths is made for each day through the period of record.

All mortality data are adjusted to account for changes in the total population of the Philadelphia SMSA during the period of record. A direct standardization procedure is used, and a mortality trend line is constructed for the period of record based on mean daily mortality for each year of record. Mortality is expressed as a deviation around this temporal baseline value (Kalkstein 1991; Lilienfield and Lilienfield 1980).

c. Relationship between synoptic categories and mortality

The mean daily mortality for each synoptic category, along with the standard deviation, is determined to ascertain whether particular categories exhibited distinctively high or low mortality values. Potential lag times are accounted for by evaluating the daily synoptic category on the day of the deaths, as well as 1, 2, and 3 days before the day of the deaths. Daily mortality is also sorted from highest to lowest during the period of record to determine whether certain synoptic categories are prevalent during the highest and lowest mortality days in Philadelphia. For many cities, it is apparent that one or two hot air masses possess a much higher mean mortality than the others, and these "oppressive" air masses contain an inordinately high percentage of days with the greatest mortality totals (Kalkstein 1991). For Philadelphia, this offensive air mass is identified as category 3 (maritime tropical, oppressive; Tables 1 and 2). This is the hottest air mass in Philadelphia during summer and is also characterized by the highest dewpoint temperature, southwesterly winds, and partly cloudy conditions. Category 3 possesses the highest mean mortality for a lag of 0 days.

While this maritime tropical air mass has a daily mean mortality well above the overall mean, not all days within this airmass type possess elevated mortality totals; the standard deviation of daily mortality is particularly high for this air mass (Table 2). Thus, the PWWS must not only identify the oppressive air mass, it must also identify which days within this air mass will have elevated mortality. Using a standard stepwise multiple regression analysis, it is possible to determine which factors within the oppressive air mass contribute to elevated mortality (Table 3). In Philadelphia, the factors contributing to elevated daily mortality when the oppressive air mass is present include:

- the number of consecutive days the air mass has been present,
- maximum temperature, and
- the time of season (e.g., whether the oppressive air mass occurs early or late within the summer season).

The resulting algorithm satisfies the Box and Wetz (1973) criteria for being a statistically robust predictor and can be used to estimate mortality for any given day.

TABLE 1. Mean meteorological characteristics for 11 summer airmass types—Philadelphia.

Category no.	Airmass type	Category frequency[a]	Time (h)	T_a °C[b]	T_d °C[c]	Atmospheric pressure (mb)	Cloud cover (tenths)	Wind[d]
1	Anticyclonic, mild	9.5	0100	20	16	1020	5	Variable, light
			0700	18	16	1020	7	
			1300	26	16	1020	7	
			1900	25	16	1018	7	
2	Cool maritime	4.4	0100	21	18	1019	8	NE, moderate
			0700	20	18	1020	9	
			1300	24	18	1020	9	
			1900	23	18	1019	8	
3	Maritime tropical, oppressive	11.5	0100	24	21	1017	4	SW, light
			0700	24	21	1017	5	
			1300	32	21	1016	4	
			1900	31	21	1014	5	
4	Cyclonic, very humid	11.1	0100	23	20	1014	8	SW, moderate
			0700	22	21	1013	9	
			1300	28	21	1013	8	
			1900	27	21	1011	8	
5	Maritime tropical, cloudy and humid	8.7	0100	23	21	1017	7	SE, light
			0700	22	21	1018	9	
			1300	29	21	1018	8	
			1900	27	21	1016	8	
6	Cyclonic, cloudy and humid	7.0	0100	24	21	1011	7	W, moderate
			0700	23	20	1010	7	
			1300	30	20	1011	6	
			1900	28	18	1010	5	
7	Anticyclonic, warm and dry	6.2	0100	21	17	1020	2	SW, moderate
			0700	20	17	1020	3	
			1300	30	18	1020	3	
			1900	29	18	1018	3	
8	Weak transition from maritime	4.7	0100	23	18	1014	4	NW, light
			0700	21	17	1016	3	
			1300	29	16	1016	3	
			1900	29	15	1016	2	
9	Modified continental	6.8	0100	20	17	1014	5	SW, light
			0700	20	17	1014	7	
			1300	27	17	1014	7	
			1900	26	17	1013	6	
10	Anticyclonic continental, cool and dry	12.9	0100	17	11	1020	2	NW, light
			0700	16	10	1021	2	
			1300	25	10	1022	3	
			1900	25	11	1020	4	
11	Transition to continental	6.2	0100	18	13	1011	4	NW, moderate
			0700	17	12	1012	4	
			1300	24	11	1013	5	
			1900	24	10	1012	4	

[a] Percent of total days within each category. Categories less than 2.0% frequency omitted.

[b] Air temperature.

[c] Dewpoint temperature.

[d] Wind direction and speed.

TABLE 2. Mean daily standardized mortality and standard deviations for Philadelphia air masses. Mean daily mortality values represent mean mortality for each air mass as expressed as a deviation around the standardized mortality baseline for all days in the summer season. Thus, for "oppressive" air mass 3, mean daily mortality was 8.8 deaths above this long-term baseline.

Category no.	Mean daily mortality	Standard deviation
1	−4.4	10.4
2	−2.6	11.5
3	8.8	17.0
4	1.6	12.5
5	−1.9	12.7
6	3.9	17.3
7	2.4	12.4
8	0.1	12.1
9	0.0	12.0
10	−4.1	12.8
11	−4.5	12.5

3. Format of the PWWS

Previously, health warnings were issued by the Philadelphia Health Commissioner if the local National Weather Service office issued an excessive heat warning based on the heat index. Unlike the NWS system, the PWWS is based on the identification of oppressive air masses that are actually associated with elevated mortality in summer.

Using NWS forecast data for upcoming days, it is possible to predict the arrival of an oppressive air mass up to 2 days before it arrives. The nested grid model (NGM) forecast issued by the NWS is used to predict the arrival (or continuance) of oppressive air masses 2 days in advance. The NGM is a 16-layer model with 80-km resolution. It generates 48-h forecasts twice a day and is used for model output statistics (MOS) guidance. These MOS values include the standard meteorological variables necessary to classify each day into one of the preexisting synoptic categories. Since the categories, and their respective means, have already been predetermined, the post-TSI classification of the forecast data requires a separate statistical technique. The use of PCA and average-linkage clustering is restricted to identifying initially the air masses at a given locale. Since the goal here is to classify each forecast day into one of the synoptic categories listed in Table 1, the appropriate tool is discriminant function analysis (Klecka 1980). Discriminant analysis is similar to the use of multiple regression. For each airmass type, a discriminant function is developed based on the means of the 24 variables. Then, for each forecast day, a discriminant score is calculated for each of the synoptic categories. The day is classified into the category possessing the highest score, which represents the most similar synoptic situation.

The accuracy of the forecast data, and the performance of the discriminant function analysis, were verified through a "backcasting" technique, in which previously issued MOS forecast data were applied. The same procedure outlined above was used; however, results from the discriminant analysis could then be compared to days already defined by the TSI, which used actual meteorological data for the same days. When 24-h forecast data were used, the backcasting technique correctly identified the oppressive synoptic category on 32 out of 36 days (88.8%) in 1988; this rate decreased to 71.4% (25/35) when 48-h forecast data were utilized. Of course, the reduction in accuracy when using the 48-h forecast data is no reflection on the backcasting technique, but rather reflects the limitations of MOS forecasting ability.

The framework of the PWWS is depicted in Fig. 1 and consists of a three-tiered system that produces a *health watch, health alert,* or *health warning.* The system is coordinated with the local Philadelphia re-

TABLE 3. Philadelphia offensive category regression analysis.

Variable	Coefficient	Prob. > F^a	Partial R^2
Maximum temperature (MT)	1.1330	0.001	0.1314
Day in season (DS)	−0.1625	0.0003	0.0578
Day in sequence (DQ)	3.1793	0.0035	0.0394

Resulting algorithm used to predict mortality (model R^2 = 0.2286): $\hat{y} = -91.6092 + (3.179DQ) + (1.133MT) - (0.163DS)$, where $\hat{y}$ represents the predicted mortality for a particular offensive category day.

[a] Only variables in model that are statistically significant at the 0.05 level are used.

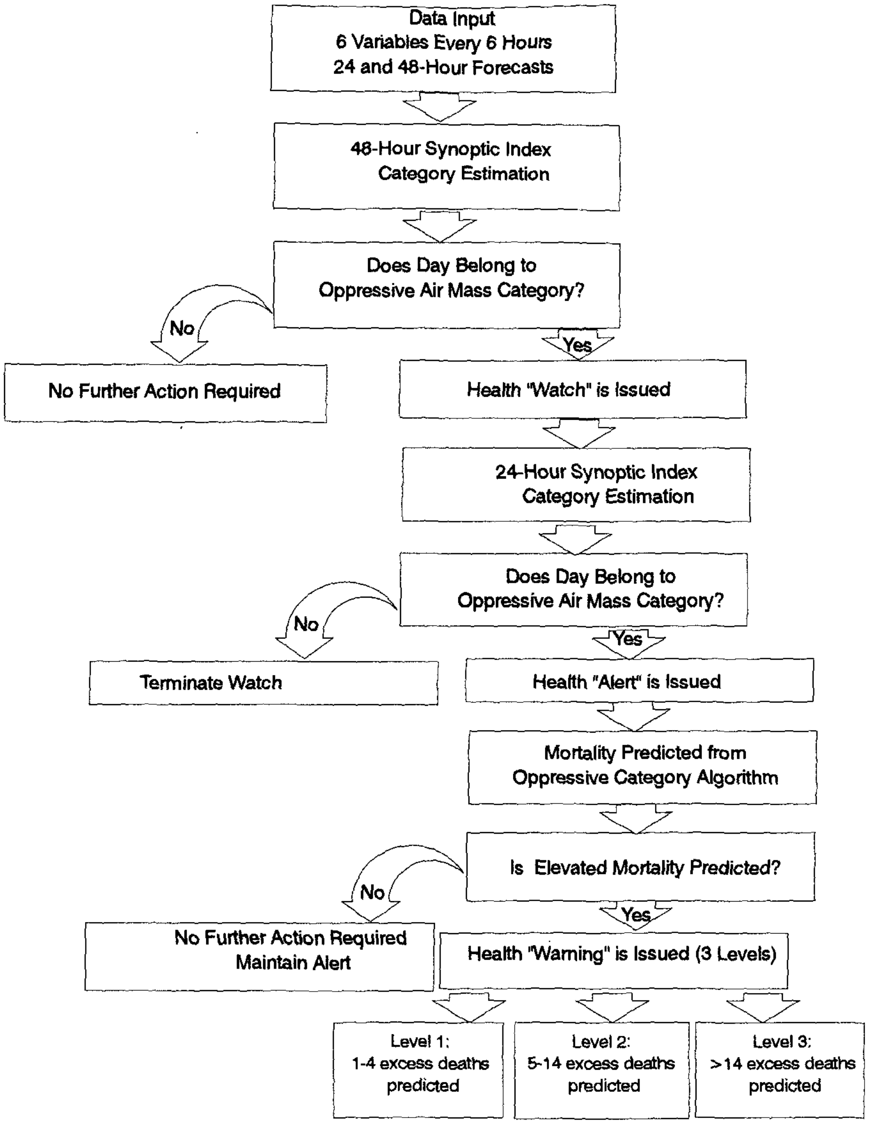

FIG. 1. Configuration of the Philadelphia Hot Weather–Health Watch/Warning System.

gion National Weather Service office in Mount Holly, New Jersey. The information is transmitted to the Philadelphia Department of Public Health from the University of Delaware's Center for Climatic Research, and after consultation with the center and the local National Weather Service office, the health commissioner makes the final decision on the issuance of health advisories.

The system is initiated with the analysis of MOS data, and airmass type is predicted for a 3-day period (today, tomorrow, and day after tomorrow) using the backcasting technique. If the procedure forecasts the arrival of the oppressive air mass for the day after tomorrow, a health watch is issued by the health commissioner up to 48 h prior to its predicted arrival. If the forecast arrival of the oppressive air mass is tomorrow, the health commissioner issues a health alert up to 24 h prior to airmass arrival. Since not all oppressive airmass days produce elevated mortality, the next level of this system involves identification of those days predicted to be associated with high daily mortality. This is accomplished by using the algorithm developed from the evaluation of mortality variance within oppressive airmass days (Table 3). A health warning is issued by the health commissioner either the afternoon before, or the morning of, the forecast occurrence of an offensive air mass *only if elevated mortality is predicted by the algorithm.* In addition, the local NWS office must agree to issue a simultaneous excessive heat warning. Depending upon the magnitude of the excess deaths predicted, one of three levels of health warning is issued (Fig. 1). For Philadelphia, a level-one warning is issued if one–four heat-related deaths are predicted by the algorithm. A level-two warning is issued if 5–14 deaths are predicted, and a level-three warning is issued if 15 or more deaths are predicted.

A series of intervention activities are initiated by the City of Philadelphia Department of Public Health and other agencies and organizations during various stages of the PWWS. These include the following:

- Media announcements: The media (TV, radio stations, and the newspapers) are contacted and informed of *all* declarations by the health commissioner and are provided with information on how to avoid heat-related illnesses during oppressive weather. The media have been cooperative, supportive, and active, both in reporting PWWS declarations and in providing information useful to the general public, including features highlighting various intervention activities.
- Promotion of the "buddy system": Media announcements encourage friends, neighbors, rela-

tives, block captains, town watch groups, church members, and other volunteers to make daily visits to elderly persons during hot weather. The "buddies" make certain that susceptible individuals have sufficient fluids, proper ventilation, and other amenities to cope with the heat wave.

- Activation of the "Heatline": When the health commissioner declares a warning, the Heatline, a hotline operated in conjunction with the Philadelphia Corporation for Aging, is activated to provide information and counseling to the general public on avoidance from heat stress. The Heatline number is publicized by the media and also on the "Crown Lights," a high visibility display seen over a large area of center city Philadelphia.
- Home visits: Department of Public Health field teams make home visits to persons requiring more attention than can be provided over the hotline (but still not requiring 911 emergency intervention).
- Nursing and personal care boarding home intervention: When a watch is declared, the Department of Public Health contacts these facilities to inform them of an impending high-risk heat situation and to offer advice on the protection of residents. In addition, during warning periods, field teams make inspection visits to these homes to ensure adequate hot weather care for residents.
- Halt of utility service suspensions: The local electric company (Philadelphia Electric Company) and the Philadelphia Water Department halt service suspensions during warning periods.
- Increased emergency medical service staffing: The Fire Department Emergency Medical Service utilizes the PWWS declarations to schedule increased staffing in anticipation of increased service demand.
- Daytime outreach to the homeless. The city's agency for homeless services activates intensive daytime outreach activities to assist the homeless on the street.
- Air-conditioned service facility capability. Senior centers extend their hours of operation to evenings and weekends. In addition, the Department of Public Health has the capability to move persons at high risk out of dangerous living situations to an air-conditioned shelter facility.

4. Does the system work?

The meteorological summer (1 June–31 August) of 1995 was the hottest on record for the city of Philadelphia, with a daily average maximum temperature near 32°C (90°F). Temperatures reached or exceeded 32°C on 22 days in July, and minimum temperatures averaged 22.5°C (72.5°F) for the month. The PWWS was instituted on 12 July 1995 and continued through 21 September 1995. During this period, the oppressive synoptic category occurred on 16 days (Table 4), with most occurrences confined to the period between 13 July and 14 August. Two particularly extreme heat episodes stand out: 13–15 July and 2–5 August. Of the 72 heat-related deaths reported by the Philadelphia medical examiner for the summer of 1995, 32 were associated with these particular heat episodes.

Fifteen of the 16 days within the oppressive synoptic category during the period were predicted to be associated with excess mortality based on the algorithm. Thus, the Center for Climatic Research (CCR) recommended to the National Weather Service and the Philadelphia Department of Public Health that warnings should be issued on these 15 days (Table 4). According to system criteria, level-two and -three warnings should have been issued on 12 and 3 days, respectively (no level-one warnings were predicted). The maximum excess mortality value was forecast to occur on 15 July (23 deaths), the third consecutive day of the oppressive air mass. A comparison of mortality totals indicates that the number of heat-related deaths forecast by the system was significantly higher than the number identified by the Philadelphia medical examiner. It should be noted, however, that the system predicted deaths for the *entire* SMSA, while heat-related deaths represent those that occurred in the city only. In addition, it is probable that some heat-related deaths were attributed to other causes and consequently not brought to the attention of the medical examiner. It is also possible that heightened awareness of the dangers of heat attributed to the severe heat wave of 1993 contributed to some reduction in mortality. However, in most cases, the system predicted heat-related deaths at times when they actually did occur. Apparent system overestimation seemed to be greatest near the end of the summer season.

Actual warnings were not issued by the Philadelphia Department of Public Health on every day the PWWS recommended that warnings be issued. Of the 15 warning days indicated by the system, actual warnings were issued on 9 days. An actual warning can only be issued with National Weather Service concurrence, and such concurrence was not offered by the NWS on 6 days. Thus, only health alerts were issued on these days; however, it should be noted that

TABLE 4. Philadelphia Department of Public Health summary of actions: Summer 1995. Level of health advisory: W = warning; W-2 = level-2 warning; W-3 = level-3 warning; A = alert; (T) = episode mortality total. Offensive category days are marked with an asterisk (*). Highlighted days are those where the CCR suggested issuing a warning and NWS did not occur. **Note:** No alerts or warnings were issued after 14 August; 1September was an offensive category day, but no heat-related deaths were predicted.

Date	CCR recom	NWS action	Health action	Heat-related deaths	Predicted excess mortality
12 July					
13 July*	W-2	W	W		8
14 July*	W-3	W	W	23(T)	15
15 July*	W-3	W	W		23
16 July					
17 July				5	
18 July*	W-2		A	5	7
19 July					
20 July*	W-2		A	4	6
21 July					
22 July					
23 July					
24 July*	W-2		A	3	6
25 July					
26 July*	W-2	W	W	1	8
27 July*	W-2	W	W	2	11
28 July					
29 July*	W-2		A	2	7
30 July					
31 July					
1 August					
2 August*	W-2	W	W	9(T)	9
3 August*	W-2	W	W		13
4 August*	W-3	W	W		19
5 August*	W-3		A		17
6 August				1	
7 August				3	
8 August					
9 August					
10 August					
11 August					
12 August*	W-2		A		7
13 August				1	
14 August*	W-2	W	W		7
Total				**72**	**163**

significant numbers of heat-related deaths occurred during these alerts.

Two notable observations are apparent relating to the application of the PWWS. First, it appears that warnings were justified on those 6 days. Five of the 6 days were associated with excess mortality, yet the Philadelphia Department of Public Health did not activate those mitigating measures that require a warning, due to a lack of NWS concurrence. The NWS did not concur on those days as they did not meet the standard heat advisory criteria (based on the heat index) that had traditionally been used by NOAA. It is suggested here that local NWS forecasters should have more flexibility in their use of established criteria to issue heat advisories and warnings. Such latitude is presumably granted to forecasters in the NWS Regional Operations Manual, where it is stated that, "at the forecaster's discretion, excessive heat warnings may be issued at a lower (heat index) threshold . . . to account for possible differences between the official temperatures reported at exposed observation sites and those within the more congested city areas" (NOAA 1994).

Second, it is noteworthy that the PWWS overpredicted mortality by a considerable margin during the hot weather of early and mid-August (Table 4). Overprediction was relatively minimal earlier in the summer season. Two possibilities are suggested. First, many susceptible individuals died during the earlier heat episodes, leaving less vulnerable individuals later in the season. This notion of "mortality displacement" is well documented in the literature (e.g., Kalkstein 1993). However, the predictive mortality algorithm used in the PWWS allows for some measure of mortality displacement as it contains a "time of season" variable, which proved to be statistically significant and inversely related to mortality (i.e., as the season proceeds, less mortality is expected given similar weather conditions). Second, it is possible that the system was effective in saving lives as the season progressed, as evidenced by the increasing overprediction of the algorithm through the period. Virtually all of the Philadelphia media broadcast the health warnings and alerts as they were issued by the Department of Public Health. Thus, public awareness of vulnerabilities to health problems related to oppressive weather was probably higher in Philadelphia than ever before.

Further evaluation of the PWWS is imperative, and the Climate Change Division of the U.S. Environmental Protection Agency is developing a comprehensive plan to determine its potential effectiveness during the summer of 1995. In addition, comparisons with other heat–mortality models, such as the "wet-bulb global temperature index" (WBGT) used in St. Louis (City of St. Louis 1994), is necessary during subsequent hot weather episodes. Finally, the NOAA Disaster Survey Team has evaluated the response of various cities (including Philadelphia) to cope with health problems during the hot summer of 1995, and their report suggests continued testing of the PWWS and expansion to additional cities. The report further recommends that, "The NOAA Chief Scientist should convene a workshop comprised of interagency physical scientists, private sector providers, social scientists, and epidemiologists, to provide operational research recommendations in light of the scientific advances made over the last decade" (NOAA 1995). The system will be initiated again for the summer of 1996 in Philadelphia, and similar systems are planned to be on-line in the near future for Chicago and Phoenix.

Acknowledgments. The development and implementation of the PWWS was possible through the support of the Climate Change Division, U.S. EPA (CR-824404), and the Southern Regional Climate Center (R-108542), and we are greatly appreciative. We are most grateful to many individuals at the Philadelphia Department of Public Health for permitting us to implement the system and having the confidence in our work to use the system as the basis for their health mitigation measures. We thank Ms. Estelle Richman, health commissioner, Dr. Allen Chandler, medical director, and Mr. Jeff Moran, director of communications, for their support. David Rodenhuis, Robert Bermowitz, and Jim Laver of the National Weather Service's Climate Prediction Center deserve special thanks for their suggestions and efforts to heighten NOAA awareness about the system. Chet Henricksen, meteorologist in charge, and his staff at the National Weather Service Forecast Office in Mt. Holly, New Jersey, were most cooperative and were instrumental in the successful implementation of the system. Finally, we thank numerous students and staff at the Center for Climatic Research who worked long hours to keep the system operational during this very hot summer.

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