POVERTY'S INFLUENCE ON WEATHER-RELATED MORTALITY

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ABSTRACT Hot weather has the potential to exacerbate existing health problems and to contribute to increased mortality. However, similar weather conditions are not debilitating in all regions or to all groups of people. This study uses a temporal synoptic procedure to examine the impact of stressful summer weather on human mortality. People living in urban poverty areas are compared to people in more affluent areas in five metropolitan regions: St. Louis, New York, Washington, New Orleans, and Atlanta. The results show that urban residence, rather than poverty alone, affects heat-related mortality in two cities, whereas suburban residents in all five cities demonstrate no response to heat.

INTRODUCTION

There has been a recent resurgence in interest among geographers regarding the impact of weather upon human health. This may be due in part to concern about global warming. This study uses a synoptic climatological analysis, while simultaneously considering sociological factors, to address the relationship between weather and human health. Synoptic climatology is useful in this type of study because weather elements act in concert, rather than individually, and the entire atmospheric situation is important.

Specifically, this study evaluates the impact of stressful summer weather on mortality for people residing in areas of urban poverty versus more affluent areas. Poverty is frequently associated with substandard housing, limited access to medical care, and poorer health in general, and thus may exacerbate heat-related mortality.

The investigation includes an examination of interregional weather-mortality responses in five metropolitan areas: St. Louis and New York, which historically have shown strong weather-mortality relationships; New Orleans and Atlanta which, typical of most southern cities, do not seem to be affected by hot weather; and Washington, D.C. which may be intermediate between the southern and northern cities.

METHODOLOGY

The test period consists of fifteen years with complete data between 1964 and 1986; several intervening years are missing data and cannot be included. The summer season analyzed includes May first through August 31. May is possibly a key month because some studies have indicated that hot weather early in the summer season, when people are not accustomed to it, may be linked to increased mortality (Kalkstein, 1988; Kalkstein and Davis, 1989).

Mortality data are from the National Center for Health Statistics (NCHS) and available only at the county level. As the NCHS data do not include income or indicate poverty status, a surrogate is needed to determine relative income. Census data are used to find poverty rates for the total county, and for blacks and whites separately, to define poor and non-poor socioeconomic groups for each of the five metropolitan areas. Poor counties are defined as those with poverty rates greater than 20 percent and non-poor counties as those with less than 8 percent. In the metropolitan counties used in this study, only blacks have poverty rates greater than 20 percent and only whites have rates less than 8 percent (Table 1). Thus high poverty level blacks are compared to low poverty level whites, with the underlying assumption that there is no documented physiological difference between the two races in their response to heat (Kalkstein and Davis, 1989). Therefore, any heat-related mortality differences should be due to other factors, such as poverty. Obviously race is not an ideal surrogate for poverty, but based on these statistics, race in the counties chosen here provides a fairly good indication of poverty.

In the five metropolitan areas examined, all poor groups reside in the city and all non-poor in the suburbs. To determine if any potential weather-mortality relationships observed are due to urban-suburban differences rather than income disparities, the higher income white and total populations of the urban counties are investigated in addition to the high poverty black population. Within each group, daily mortality rates are calculated for all ages, as well as for the elderly, who are defined as anyone 65 years or older, to determine if the elderly are affected differently by hot weather than the total population.

Weather data are from the National Climatic Data Center (NCDC), and include four daily measurements of air temperature, dewpoint temperature, wind speed and direction, atmospheric pressure, and cloud cover.

Two methods are used to determine if weather-mortality relationships exist. The first, based on daily maximum temperature alone, determines if a "threshold temperature" exists, above which mortality dramatically increases. The threshold temperature is calculated statistically by determining the correlation between maximum temperature and mortality and then finding the total sum of squares error (TSS) for each temperature (Kalkstein, 1988). The threshold temperature is defined as the temperature with the smallest TSS, and exists only if there is a relationship between maximum temperature and mortality.

TABLE 1: County Level Poverty Rates, by Race[a]

SMSA	State	County	Total	White	Black
Atlanta	GA	Clayton	8.0	7.0	21.1
		Cobb	6.3	5.4	24.2
		De Kalb	9.7	5.7	19.9
		Fulton	21.2	19.5	40.3
New Orleans	LA	Jefferson	9.5	6.5	26.3
		Orleans	26.4	11.5	37.3
		St.Bernard	8.9	7.8	37.6
New York City	NY	New York (all boroughs)	20.0	12.9	29.6
		Nassau	4.8	3.8	17.0
		Suffolk	6.6	5.8	17.7
St. Louis	MO	St. Louis	4.9	3.6	14.0
		St. Louis City	21.8	11.6	33.6
	IL	Madison	9.8	8.5	30.2
		St. Clair	17.7	8.5	41.6
Washington,D.C.	DC	District of Columbia	18.6	9.3	22.0
	MD	Montgomery	4.3	3.3	11.8
		Prince George's	6.7	5.3	8.6
	VA	Fairfax	3.9	3.2	12.2

[a] U.S. Department of Commerce, 1980b.

The second method utilizes an automated synoptic method, known as the temporal synoptic index (TSI), to group days into air masses (Kalkstein et al., 1987). This procedure uses principal components analysis to reduce the 24 original variables to a fewer number of orthogonal components. Then a clustering procedure is used to classify meteorologically homogenous days together into air masses for which mortality rates can then be identified. Next, it is determined which air masses, if any, are linked to high mortality and thus can be considered "offensive". These air masses frequently occur on days with high mortality and have high mean mortality rates and large standard deviations, indicating that they comprise the highest mortality days, but also some days with lower mortality.

Mortality rates are isolated for days above the threshold or during which an offensive air mass is present. These days are used in a stepwise multiple regression to determine which variables may contribute to high mortality. Several variables are used in the regression, including two non-climatological ones (Table 2). The variable "time in season" (TIME) compares the impact on mortality of hot days early in the summer season to those later in the season, and the variable "consecutive day" (REP) determines if a hot day occurring after several days of hot weather is more stressful than a single, isolated day with a high temperature.

TABLE 2: Multiple Regression Variables

Variable	Abbreviation
Maximum Temperature	MAXT
Minimum Temperature	MINT
Maximum Dew Point Temperature	MAXDPT
Minimum Dew Point Temperature	MINDPT
Afternoon Wind Speed	WSPM
Afternoon Cloud Cover	CCPM
Time in Season[1]	TIME
Consecutive Day[2]	REP

[1] May first has a value of one, and August 31 of 123.

[2] If June 15 is above the threshold temperature, it has a value of one.
If June 16 is also above the threshold, it has a value of two. The same is true for offensive air mass days.

RESULTS

For New York and St. Louis, the threshold and synoptic methods both identify weather-mortality relationships for the poor, affecting the elderly as well as the total population. However, the non-poor do not exhibit a response. Figures 1a and 1b, for New York, show how mortality rates for the poor of all ages rapidly increase above the threshold temperature of 89°F, while there is no temperature-mortality relationship for the non-poor. A similar association is found in St. Louis. In Washington, New Orleans, and Atlanta, maximum temperature does not affect mortality for either the poor or the non-poor.

The synoptic method produces similar results. In New York, air mass 110 has a noticeably higher mean mortality and standard deviation for the poor than any other air mass, but no one air mass can be considered offensive for the non-poor (Figures 2a and 2b). The elderly have a similar relationship. In St. Louis air mass 102 is also offensive for the poor only.

Figure 1a. New York Poor Mortality vs. Maximum Temperature
(All Ages)

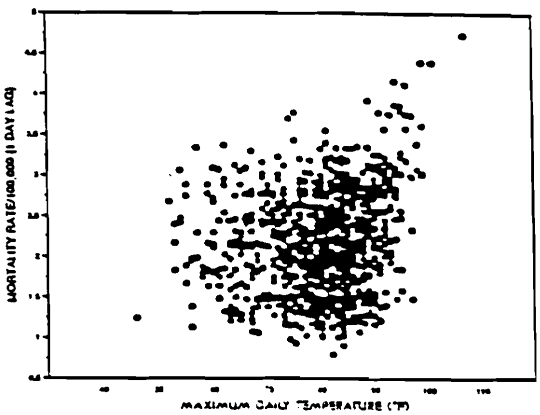


Figure 1b. New York Non-Poor Mortality vs. Maximum Temperature
(All Ages)

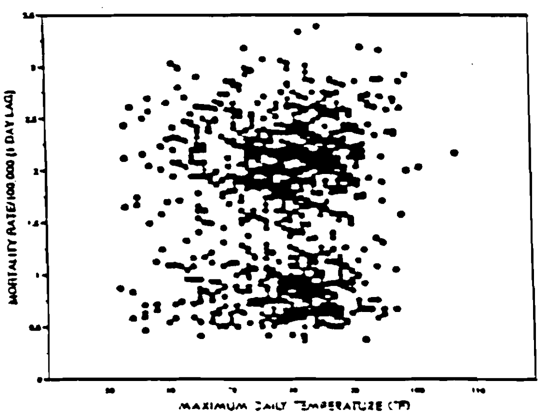


Figure 2a. New York Air Masses
Mean Mortality Rates (All Ages)

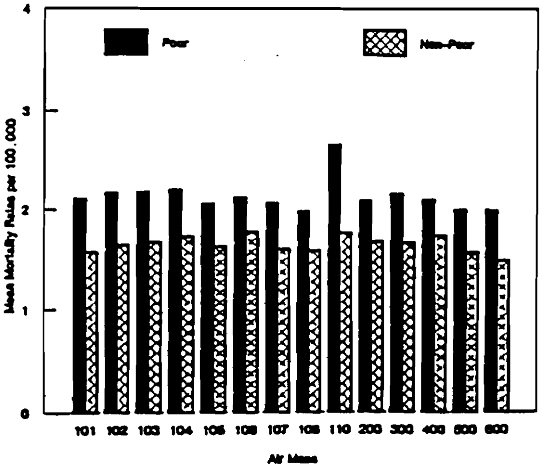
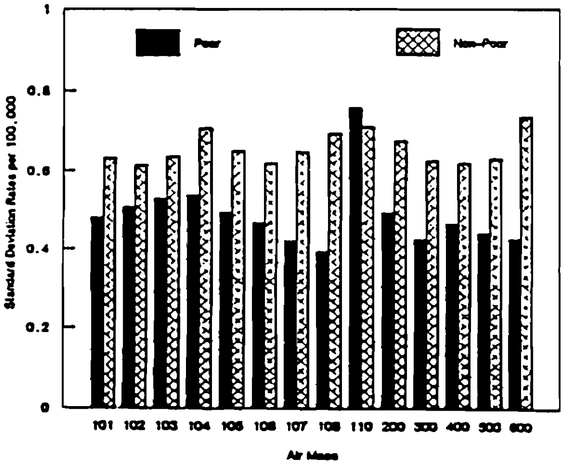


Figure 2b. New York Air Masses:
Mortality Standard Deviations (All Ages)



Investigation of all races in urban New York and St. Louis shows that whites, as well as the total population, are affected by hot weather. For all groups within the urban counties of both cities, there is a threshold temperature and the same offensive air masses as for the poor residents. Thus, heat affects urban residents regardless of income but has no impact on suburban residents.

Regression results for offensive air mass days show that high temperature is the single most important variable in explaining heat-related mortality in New York and St. Louis (Table 3), although low afternoon wind speed and low maximum dewpoint are also significant. In St. Louis, time in season is inversely related, indicating that episodes of hot weather occurring early in the summer season, rather than later on, are particularly stressful. In urban New York, the R^2 values for the elderly and all ages populations are fairly high (about 62%), but are much lower for St. Louis (about 20%).

TABLE 3: Offensive Air Mass Multiple Regression			
New York Urban County, All Races, All Ages (Air Mass 110)			
Variable	Coefficient	Partial R^2	Prob > F
MINT	0.221	0.413	0.0001
MAXT	0.150	0.114	0.0021
WSPM	-0.081	0.073	0.0076
MAXDPT	-0.107	0.056	0.0126
Model Adjusted R^2 = 0.623			
St. Louis Urban Counties, All Races, All Ages (Air Mass 102)			
Variable	Coefficient	Partial R^2	Prob > F
MAXT	0.089	0.172	0.0001
TIME	-0.008	0.026	0.0033
WSPM	-0.033	0.012	0.0487
Model Adjusted R^2 = 0.201			

DISCUSSION

This study finds no evidence of a significant relationship between poverty and heat-related mortality, although urban residence is important. In urban New York and St. Louis, blacks, who have high poverty rates, respond similarly to whites, who have much lower rates. Thus in New York and St. Louis, urban dwellers are adversely affected by the heat regardless of socioeconomic status, while suburban residents show no response. Although it is possible that extreme poverty could exacerbate heat-mortality effects, the available data make it difficult to isolate high poverty death rates. Census tract level mortality data would be useful if available.

Regression results show that high temperatures have the greatest impact on summer mortality of all variables investigated. However, in New York, low afternoon wind speed and low maximum dewpoint also are important, suggesting that hot, dry days with little ventilation are particularly debilitating. In St. Louis, hot days with low afternoon wind speed that occur early in the summer season, when people are unaccustomed to high temperatures, are linked to heat-related mortality.

The absence of a weather-mortality relationship for New Orleans and Atlanta reaffirms preceding findings for southern cities, but the lack of an association between mortality and weather for Washington is difficult to explain. There are several possible explanations for the different heat-mortality responses observed in the five cities.

Physiological acclimatization may explain the lack of a heat-mortality response in New Orleans and Atlanta. Because these southern cities are frequently subjected to hot weather, urban and suburban residents alike may have become acclimatized to conditions that could be stressful in urban areas further north. However, it is implausible that residents in Washington are more acclimatized to hot weather than those in St. Louis, since the climates are similar. Therefore, other factors, such as city structure and housing type may be more influential in Washington.

Another possible explanation for differences in urban and suburban weather-mortality rates could be the urban heat island. Urban areas often have higher temperatures than surrounding suburban areas (Landsberg, 1981), which could intensify the impact of hot weather. However, the urban heat island does not explain the lack of an urban heat response in Washington or the southern cities. Comparison of urban and suburban air temperatures in the five cities would show if differences in magnitude exist.

Interregional differences in housing type are probably important as well. In New York, there are many high-rise apartment complexes (U.S. Department of Commerce, 1980a), which may have reduced ventilation inside and thus elevate heat stress. St. Louis has many red brick row houses with black roofs that would trap heat inside and make living conditions uncomfortable. Since these two cities experience cold winters, it is likely that the housing stock is more appropriate for keeping out cold weather than for alleviating hot conditions. However, Atlanta and New Orleans are more likely to have detached houses that may have high ceilings or many windows, which can help increase ventilation. Housing stock in Washington varies, but seems more similar to St. Louis than to Atlanta or New Orleans and does not readily account for the lack of an urban heat-mortality relationship there.

CONCLUSION

This study finds no evidence that poverty influences heat-related mortality, although urban and suburban as well as regional differences are found. Housing type may explain why urban residents of New York and St. Louis are adversely affected by the heat while suburban inhabitants are not. Interregional differences may be partially due to physiological acclimatization, which most likely contributes to higher heat tolerance in southern cities. The next step of this research is to investigate regional housing differences in greater detail by looking at census housing data, such as population density, the age of the structure, the number of units in the building, or the availability of air conditioning.

REFERENCES

Kalkstein, L.S., 1988. The Impacts of Predicted Climate Changes upon Human Mortality. Publications in Climatology 41:1-110.

Kalkstein, L.S. and R.E. Davis, 1989. Weather and Human Mortality: An Evaluation of Demographic and Inter-regional Responses in the United States. Annals of the Association of American Geographers 79:44-64.

Kalkstein, L.S., G. Tan, and J. Skindlov, 1987. An Evaluation of Objective Clustering Procedures for use in Synoptic Climatological Classification. Journal of Climate and Applied Meteorology, 26:717-730.

Landsberg, H.M., 1981. The Urban Climate. New York: Academic Press.

U.S. Department of Commerce. Bureau of the Census, 1980a. 1980 Census of Housing. Detailed Housing Characteristics. Washington: U.S. Government Printing Office.

___________. Bureau of the Census, 1980b. 1980 Census of Population. General Social and Economic Characteristics. Washington: U.S. Government Printing Office.