12.6 USING A SYNOPTIC CLASSIFICATION SCHEME TO ASSESS RURAL-URBAN DIFFERENCES IN HEAT VULNERABILITY

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1. INTRODUCTION

Research on human vulnerability to extreme weather conditions has utilized a variety of techniques and discovered a number of important factors that explain the variability observed. Much of this work has focused upon parameters that are national or regional in scale, such as acclimatization (*e.g.* Kalkstein and Greene 1997) as well as cultural perception (*e.g.* Eurowinter Group 1997). Little research has examined spatial patterns on a sub-metropolitan area scale; the research that has suggests several factors, including age and income level, may be important (Smoyer 1998). One common assumption made throughout much research is that, especially regarding oppressive heat, urban residents are more significantly affected than rural residents. Events such as the heat wave of July 1995 that was responsible for the deaths of several hundred Chicagoans have supported this notion.

This research represents an initial analysis into heat-related vulnerability on a sub-metropolitan area level, by examining county-level mortality rates across the state of Ohio. Contrary to popular belief, while urban areas do appear to be more vulnerable in terms of absolute numbers of excess deaths, relative to the population as a whole, rural and urban areas seem to be affected similarly, with "oppressive" days generally associated with mortality 5 percent above normal levels.

2. DATA

Mortality data have been obtained from the National Center for Health Statistics (NCHS) for the state of Ohio for the period 1975-1998. As this study examines only heat-related mortality, solely the period from 15 May to 30 September is analyzed. For each individual death, information on date, county, cause(s), age, sex, and race are available. As evidence has shown that mortality rates of numerous causes increase during oppressively hot conditions, no stratification by cause of death is made in this work. Also, initial work has not yet uncovered any differences in heat vulnerability between the sexes and among races. Thus, for this paper, only stratification according to age is made, with those above 65 considered separately in addition to the response of the entire population.

This research utilizes a synoptic approach, by holistically categorizing days into weather types. In particular, the Spatial Synoptic Classification (SSC) is used (Sheridan 2002; more information is available at http://sheridan.geog.kent.edu/ssc.html). The SSC classifies each day at a particular location into one of seven weather types, or a transitional situation. For the purposes of this research, only two weather types are examined, both of which have been previously found to be "oppressive":

- **DT (Dry Tropical)**, featuring hot and dry conditions with high insolation values, and
- **MT+ (Moist Tropical Plus)**, very warm and very humid, with very high overnight temperatures.

These two weather types are among the least commonly occurring in Ohio, together accounting for approximately 7 percent of summer days. Mean conditions associated with these weather types are listed in Table 1.

3. METHODOLOGY

For each county, a "baseline" level of mortality for each summer from 1975 to 1998 is calculated. Mean daily mortality for each year is calculated, and a linear regression equation is then fit to these means to provide a baseline for each summer. This equation's value is then subtracted from each day's mortality to yield a value of "anomalous mortality" for that particular day.

For each weather type, mean anomalous mortality is calculated, both in terms of absolute number of deaths and percentage above or below the baseline. The weather type from the nearest available first-order weather station is used. In many cases, rural county mortality is below 1 death per day; in three counties, less than 0.5 deaths per day. To make results from these rural counties more robust, adjacent rural counties have been clustered together.

Table 1. Mean 0500 and 1700 temperature (°C), 1700 dew point (°C), and daily cloud cover (tenths) in July for the two weather types analyzed in this research for three Ohio cities.

DRY TROPICAL

City	T_{17}	Td_{17}	T_{05}	CC
Cleveland	33	16	20	3.7
Columbus	35	15	21	3.7
Cincinnati	36	16	23	3.4

MOIST TROPICAL PLUS

City	T_{17}	Td_{17}	T_{05}	CC
Cleveland	31	22	23	4.4
Columbus	33	22	24	3.9
Cincinnati	33	23	24	3.8

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4. **RESULTS**

For both of the weather types examined, statistically significant increases ($p<.01$) in mortality are noticed statewide, associated on average with 19.6 (DT) and 22.8 (MT+) additional deaths above the baseline. In terms of absolute numbers, as expected, the urban centers contain the largest values. For the Dry Tropical weather type (Figure 1), the top five counties, all of which contain large cities, account for nearly half of the increase in mortality: Hamilton (Cincinnati, 3.1 deaths),

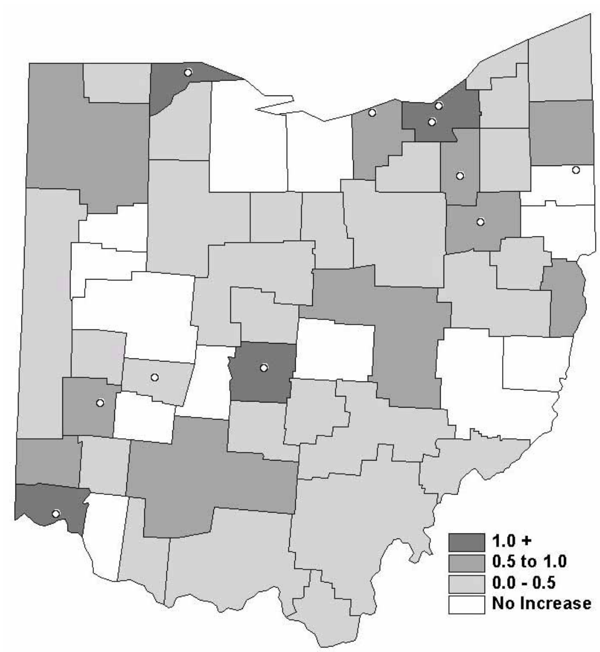

Figure 1. Mean anomalous mortality, total population, (deaths/day) associated with the DT weather type by county or rural county aggregate. Cities with greater than 80,000 population shown as circles.

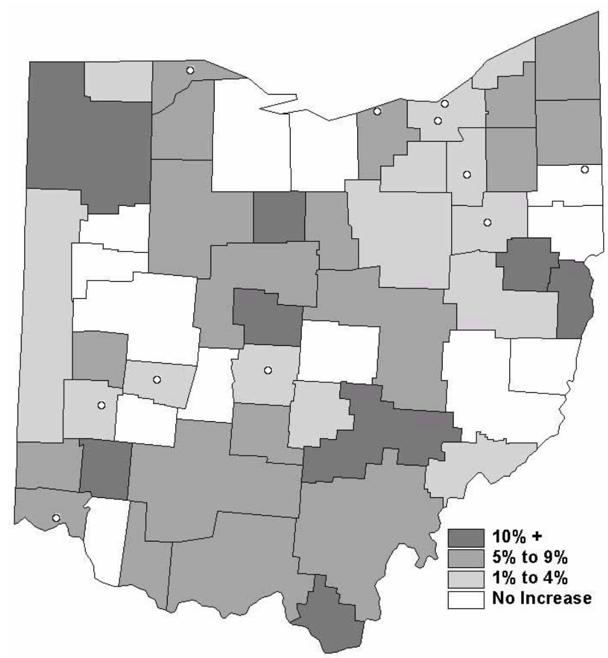

Figure 3. Same as Figure 1, except for percentage increases above baseline levels for the DT weather type.

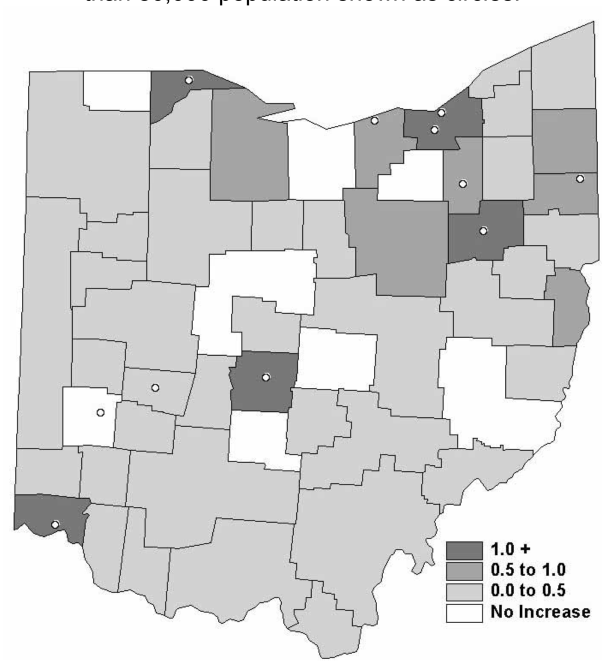

Figure 2. Same at Figure 1, except for the MT+ weather type.

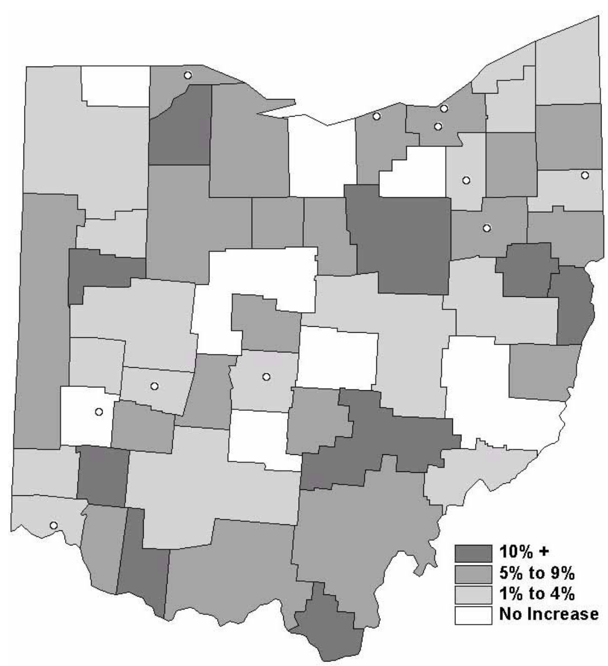

Figure 4. Same as Figure 3, except for the MT+ weather type.

Cuyahoga (Cleveland, 2.3), Lucas (Toledo, 1.4), Franklin (Columbus, 1.1), and Summit (Akron, 0.9). For Moist Tropical Plus (Figure 2), the results are similar: Cuyahoga (4.2 deaths), Hamilton (2.2), Lucas (1.6), Franklin (1.3), and Stark (Canton, 1.3).

In terms of percentage values, however, these urban counties are not as noticeable (Figures 3 and 4). For both weather types, most urban counties show a 3 to 7 percent increase in mortality. Suburban and rural counties show a much wider range in percentage changes, although the overwhelming majority is positive, with little discernible pattern across the state.

5. DISCUSSION

These results show that while the urban population is affected in greater numbers, relative to the population of each location, the increase in mortality rates is roughly equal (Table 2). Indeed, the increase in mortality with both weather types is significant at α=.01 for aggregates of all urban, suburban, and rural counties. The percentage increase is actually greater in rural counties, although the difference is not statistically significant.

Within the rural/urban divisions there are still considerable differences observed. Clearly, some urban areas are more affected than others. The older urban areas, particularly Cleveland, Toledo, and Cincinnati, are more significantly affected than Columbus, a newer city with fewer older houses. Dayton (Montgomery County) does not appear to be affected significantly with either weather type, though as one of Ohio's older cities, it is unclear why this is the case.

Among the rural and suburban counties, as mentioned, there is much more variability. There is a tendency for counties within the northern part of the state to be more significantly affected than those in the southern part of the state, particularly the hilly southeast, though this is by no means absolute. More significant results are also found with the MT+ weather type (34 counties of 88 significant at α=.01) than DT (21 counties). As MT+ is also somewhat more common than DT, this suggests that in rural counties perhaps the extreme heat of DT days is more conducive to precautions being taken than the extremely high humidity associated with MT+ days.

Table 2. Mean anomalous mortality (deaths/day) and percentage change relative to baseline by urbanization level of county. Urban counties include the center cities of all metropolitan areas; suburban counties include all other counties in the metropolitan areas; rural counties include all counties not classified as part of a metropolitan area.

DRY TROPICAL WEATHER TYPE

Location	Deaths	Percentage
URBAN	11.4	3.5%
SUBURBAN	3.9	4.1%
RURAL	4.3	5.1%

MOIST TROPICAL PLUS WEATHER TYPE

Location	Deaths	Percentage
URBAN	13.3	4.1%
SUBURBAN	5.6	5.8%
RURAL	3.9	4.7%

6. FUTURE RESEARCH

It is clear the key to understanding the spatial variability observed in heat vulnerability is by accounting for differences among the counties aside from their urban/rural character. A preliminary test showed that counties with a greater percentage of housing built prior to 1950 had greater increases in mortality with oppressive weather conditions, though this is only significant at α=.15. Other factors, including income level and percentage of those not in the work force may also help clarify the differences.

Finally, much more localized data are needed. Presently no data are available from the federal government at a level below county, or city if the population is greater than 100,000. County agencies will need to provide smaller scale data in order for a full study to be undertaken.

ACKNOWLEDGMENTS

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