Relationship Between Ambient Temperature and Humidity and Visits to Mental Health Emergency Departments in Québec

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Objective: **This study examined whether the number of emergency department visits for "mental and psychosocial problems" varies with temperature or humidity.** ***Methods:*** **The number of visits in three geographic areas of Québec were examined as a function of temperature and humidity by using routinely collected May–September data for 1995–2007 (N=347,552 visits). Data for two age groups (under age 65 and age 65 and older) were examined. Incidence rate ratios for mean temperature and humidity were estimated by using Poisson regression and generalized additive models.** ***Results:*** **The number of visits tended to increase with increasing mean temperature. At 22.5°C (72.5°F) and 25° C (77.0°F), the number was usually significantly higher than average. Visits increased with humidity in the younger age group.** ***Conclusions:*** **Results suggest increased use of emergency departments for mental and psychosocial problems with higher mean temperature and humidity, especially in metropolitan areas and in southern Québec. Climate change may make this effect increasingly important. (*Psychiatric Services* 63:1150–1153, 2012; doi: 10.1176/appi.ps.201100485)**

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Relatively few studies have examined emergency department utilization for mental health reasons during heat waves. However, studies from many countries, including the United States (1), Australia (2), France (3), Israel (4), and Spain (5), have found increasing use with increasing temperature. Another study did not report an increase in the overall number of emergency department visits but noted more visits by patients with psychiatric histories, more violent behavior, more dangerousness toward others, more drug and alcohol abuse, and increased use of restraints (6).

The purpose of our study was to examine the relationship between temperature and humidity and emergency department visits for mental and psychosocial problems in Québec, where hot temperatures are much less frequent on average than in the above-mentioned countries. To our knowledge, such a study has not been conducted elsewhere in Canada. Findings would have implications for managers of medical and psychiatric emergency services, particularly if important information and conclusions regarding weather and emergency department use can be derived from routinely gathered data that are readily available from emergency departments and meteorological services.

Methods

The study examined emergency department visits in three geographic areas of Québec from 1995 to 2007, corresponding to 13 years of data for each area for the months of May to September, excluding the winter months when temperatures are below the range we wished to study. The study used administrative data routinely collected by Québec hospitals on emergency department visits for which the patient was allocated a stretcher. The data were verified by administrators of the government database under a specific protocol (7). The variable of interest was a major group of diagnoses in the database labeled "mental and psychosocial problems," which refers to principal medical diagnoses at discharge from the emergency department or transfer to another facility and includes psychotic disorders; psychotic states; neurotic, personality, and nonpsychotic problems; drug abuse and dependence; depression; neurosis; sexual problems; voluntary intoxication; and some less frequent diagnoses (7).

The sample was restricted to persons age 15 years and older. In the

database, age was stratified into five groups: 15–24, 25–44, 45–64, 65–75, and over 75. Because heat may affect younger and older persons differently, we fitted separate models for persons under 65 and those age 65 and older.

The overall geographic area studied included all 16 health administrative regions of Québec except northern Québec (region 10). In a previous study, these administrative health regions were grouped into four meteorologically homogeneous areas, by using the method of Martel and colleagues (8), on the basis of historical data for 1981 to 2005. [A map and a population table of these areas are available in an online data supplement to this report.] Meteorological data for the inhabited areas of these regions was provided by Environment Canada and the Ministry of Sustainable Development, Environment, and Parks. Clustering allows grouping of regions with similar climates to create areas in which the number of daily events of interest is sufficiently high to analyze with generalized additive models. For meteorological variables, data from available weather stations were interpolated to improve data quality before aggregating into the larger areas. Here we report data on emergency department visits for three of the four areas; no markedly elevated mean temperatures were observed in the fourth area (largely the northern and maritime sections of Québec).

The independent variables of interest were daily temperature and relative humidity. To account for the correlation between the daily minimum and daily maximum, temperature and humidity were transformed into daily mean and daily range. Maximum temperatures generally occurred during the day, and minimum temperatures occurred during the night. The daily mean was calculated as the daily maximum plus the daily minimum divided by 2. The range was the difference between the two—that is, the daily maximum minus the daily minimum. Calculations for humidity were similar. We did not use the humidex, the apparent temperature, or any other derived variable that integrates temperature and humidity because the formulation and interpretation of such variables differ from country to country.

Other covariates included age group, sex, calendar year, and day of the week. The climatic variables were averaged over the index day and the preceding three days to represent the burden of persistent heat. Because of expected nonlinearity, Poisson modeling in a generalized-additive-model framework was used to analyze the relationship between mean daily temperature and emergency department visits. A negative binomial model was used when there was overdispersion. Estimation was performed by using penalized likelihood with cubic splines for continuous variables. The smoothing parameter was selected to minimize the Akaike information criterion (9). The data analysis was performed using R and the mgcv package for generalized additive models (10).

For a specific geographic area and age group, we calculated the incidence rate ratio (IRR) at specific temperatures and levels of relative humidity. The IRR is the ratio of the daily rate of emergency department visits for the geographic area and age group at the specific temperature or relative humidity and the overall mean rate of emergency department visits during the warm seasons for the same geographic area and age group, with all other factors being held equal. We used the overall warm-season mean of emergency department visits because the geographic variability of thresholds at which morbidity and mortality increase suggested that we not use a predetermined reference temperature. For example, in a particular geographic area, if the overall warm-season mean of emergency department visits is 50 persons per day, an IRR of 1.05 at 25°C indicates that at 25°C, with all other factors being equal, there is a 5% increase, or an excess of 2.5 persons per day, compared with the overall warm-season mean incidence rate for the region. The comparison with the overall warm-season mean was chosen because it specifically excludes winter and the colder portions of spring and fall, when morbidity and mortality rates tend to increase with colder temperatures for entirely different reasons.

Results

The total number of emergency department visits for mental and psychosocial problems for the months of interest between 1995 and 2007 was 347,552. Table 1 presents the IRRs at 20°C (68°F), 22.5°C (72.5°F), and 25°C (77.0° F) for emergency department visits for mental and psychosocial problems in each of the three geographic areas for persons under age 65 and age 65 and over. For all areas, all IRRs increased monotonically with increasing temperature. In most cases, the IRRs at 22.5°C and at 25°C were significantly higher than

Table 1

Incidence rate ratios (IRR) for number of visits to an emergency department in three geographic areas, by mean daily temperature and age group, 1995–2007[a]

	20°C		22.5°C		25°C	
Area and age group	IRR	95% CI	IRR	95% CI	IRR	95% CI
1						
<65	1.00	1.00–1.01	1.02	1.02–1.03	1.05	1.03–1.07
≥65	1.00	.98–1.02	1.03	1.01–1.06	1.09	1.03–1.15
2						
<65	1.00	.99–1.01	1.02[b]	1.00–1.03	1.03	1.01–1.06
≥65	1.00	.98–1.03	1.06	1.03–1.10	1.09	.99–1.19
3						
<65	1.02[b]	1.00–1.03	1.03	1.01–1.05	1.04[b]	1.00–1.09
≥65	1.03	1.00–1.05	1.04	.99–1.08	1.05	.98–1.12

[a] Visits were for mental health or psychosocial problems.
[b] Statistically significant by 95% confidence interval (CI) before rounding to 2 decimal places.

unity. As explained above, this means that for a given geographical area and age group, the incidence rate of visits at that temperature was significantly higher than the overall warm-season mean. The IRRs at different temperatures and levels of humidity can be directly compared. For example, the IRRs at 22.5°C and 25°C were higher than the IRRs at 20°C for several of the comparisons, as suggested by nonoverlap of 95% confidence intervals (CIs). In some cases, the increase in IRR was substantial. For example, for the group age 65 and over in area 1, Montréal and Laval, the IRR at 25°C (IRR=1.09, 95% CI=1.03–1.15) was 9% higher than that at 20°C (IRR=1.00, 95% CI = .98–1.02); the nonoverlap of CIs suggests that this is a statistically significant difference.

A table presenting IRRs at 70%, 80%, and 90% humidity is available in the online data supplement. In most cases, the IRRs increased monotonically with increasing humidity. In one case, the IRR at 70% was significantly lower than unity, and in some cases the IRRs at 80% and 90% were significantly higher than unity. Again, the increase in IRR was substantial in some cases. For example, for the group under age 65 in area 2, southern Québec (except for Montréal), the IRR at 90% humidity (1.10) was nearly 10% higher than that at 80% humidity (1.00).

The online data supplement also includes tables with data on all visits for mental and psychosocial problems by area, stratified by age and sex, and summary statistics for temperature and humidity by area. Figures illustrating the relationships between temperature and visits and between humidity and visits in area 1 for persons under age 65 are available in the online supplement. The relationships are typical of those found in the other two areas. It is notable that for temperature, the frequency of visits was high or low at the lowest temperatures studied, and after a threshold was reached, the frequency tended toward an increase or acceleration of increase. In contrast, visits tended to be low at low humidity and climbed almost linearly with increasing humidity.

Discussion

Higher temperature and humidity were associated with statistically significant and primarily monotonic increases in emergency department visits for mental and psychosocial problems in three meteorologically homogeneous areas of Québec. For temperature, significant increases were seen both for persons under age 65 and for those age 65 and older in two geographic areas; in one area the increases were seen only for those under 65. For humidity, significant increases at one or both of the higher humidity levels were seen for those under age 65 in all three geographic areas.

Effects were most notable in the metropolitan and suburban Montréal area (area 1) and in the southern Québec area (area 2) and weaker in the midlatitude area of Québec (area 3). Even over the narrow average temperature range of 5°C, increases in emergency department visits with temperature were substantial, reaching almost 9% for older individuals in area 1, the Montréal area. For younger individuals in the Montréal area, the increase was nearly 5%. For humidity, from 70% to 90% relative humidity, a significant increase was noted for persons under age 65 in all three areas. The increase was substantial in area 2 (nearly 10%).

Similar findings have been reported in other studies. In the United States, Santiago and colleagues (1) reported a statistically significant direct relationship between ambient temperature and emergency department visits, mainly among patients who were subsequently discharged rather than admitted. Multivariate stepwise linear regression suggested that average temperature accounted for 3.5% of the total variance in emergency department visits. In Australia, Hansen and colleagues (2) reported that above a threshold of 26.7°C (80.1°F) maximum daily temperature, admissions between 1993 and 2006 for behavioral and mental disorders increased with temperature, with 7.3% more admissions during heat-wave periods than during non–heat-wave periods. However, more than half of these admissions were for causes such as *ICD-9* and *ICD-10* dementia, delirium, organic brain syndrome, and senility. It is less clear to what extent schizophrenia and mood disorders were overrepresented. This is important, because in Québec delirium and dementia are often managed by medical services rather than psychiatric services.

Similar results have been found in other countries, but not in all studies. A recent study of 3,048 hospital emergency department visits during the 2003 European heat wave in Spain found a direct relationship between environmental temperature and humidity and the number of patients seen (5). Another study of two psychiatry emergency departments in Spain found no differences in the number of psychiatric emergencies or admissions; however, there were more visits by patients with psychiatric histories, more violent behavior, more dangerousness toward others, more drug and alcohol abuse, and increased use of restraints (6). In France during the same 2003 heat wave, an increase over the previous year was noted in the proportion of patients visiting psychiatric emergency departments who required admission to the psychiatry department—32.1%, compared with 15.4% for the same period in 2002 (3). A study in Israel found that psychiatric admissions for patients with schizophrenia were higher in the summer and that admission rates were correlated with the mean maximal monthly temperature (4). Similarly, a study from India reported higher psychiatric service use in summer and autumn, especially by patients with mood disorders, when temperatures were highest (11).

Excessive heat may affect the course of mental illness through increased fatigue and irritability and impaired sleep, recreation, and social interaction. Moreover, individuals with mental illness are also at increased risk of heat-related illness (12,13). Recognition of heat and thermoregulation may be altered among these individuals (14,15). Behavioral adaptations to heat may be impaired; affected individuals may live alone and may have deficits in self-care and social support, all known risk factors for heat-related illness.

Several other factors may influence heat vulnerability among persons with mental illness [additional studies are listed in the online supplement.] Persons with mental illness may not drink sufficient liquids, wear lighter clothing, seek out cool places, or take extra baths or showers. Some may dress in many layers of clothing, and persons with paranoid, avoidant, schizoid, or agoraphobic symptoms may be reluctant to leave home. Poverty may preclude access to air conditioning and transportation. Housing may be situated in disadvantaged areas located in micro-urban "heat islands." Persons with serious mental illness have a greater burden of comorbidity (for example, obesity, smoking, hypertension, dyslipidemia, diabetes, and cardiovascular disease), receive worse care, and have lower life expectancy than the general population. Many medications can affect thermoregulation, through several possible mechanisms. The preoptic nucleus of the anterior hypothalamus regulates temperature and has dopamine, norepinephrine, serotonin, and alpha-adrenergic receptors. Drugs that affect these neurotransmitters may influence thermoregulation, and some can cause malignant hyperthermia, neuroleptic malignant syndrome, or serotonin syndrome. In addition, anticholinergic medications may inhibit sweating, leading to loss of evaporative cooling, and some drugs (prescribed or not) cause cutaneous vasoconstriction, which can impair heat loss.

A strength of our study is that we used population-based administrative and meteorological data that should be widely available in a range of settings. Because of the acute nature of heat-related illness, emergency department data may be superior to hospital admission data; hospital admissions may be affected by delays due to lack of beds or lack of psychiatrists in certain regions, and admission data may not capture the rapid evolution of heat-related illness. Similar analyses can be performed in most clinical settings to help plan and manage emergency departments and preventive programs.

A limitation of our study is the lack of detail available in the aggregate data regarding diagnosis and type of hospital. A more detailed diagnosis—rather than "mental and psychosocial problems"—and more detailed data on hospital type (psychiatric versus general hospital) may improve understanding of the specific problems that lead persons to seek emergency mental health assistance. Recently, more detailed daily diagnostic data from Québec emergency departments has become available and may allow closer analysis.

Conclusions

Even within a relatively narrow band of temperature and humidity, our study found that in certain regions of Québec, especially southern Québec and metropolitan areas, increasing ambient temperature and humidity are a risk to individuals with mental disorders and are associated with increased use of emergency services for mental and psychosocial problems. This finding has important implications for managers of medical and psychiatric emergency services, particularly because, as we have shown, important information and conclusions can be derived from readily available data routinely gathered by emergency departments and meteorological services. Given evidence supporting the existence of climate change, this effect may become increasingly important.

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