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Not so little differences: variation in hot weather risk to young children in New York City

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ABSTRACT

Objectives: High ambient temperatures are associated with significant health risk in the United States. The risk to children has been minimally explored, and often young children are considered as a single age group despite marked physiologic and social variation among this population from infancy through preschool. This study explored the heterogeneity of risk of heat among young children.

Study design: Using a time-stratified, case-crossover design, we evaluated associations between maximum daily temperature (Tmax) and ED visits (n = 1,002,951) to New York City (NYC) metropolitan area hospitals for children aged 0–4 years in May–September, 2005–2011.

Methods: Conditional logistic regression analysis estimated risks for an interquartile range of Tmax for 0–6 lag days. Stratified analyses explored age strata by year, race/ethnic groups, and diagnostic codes. Sensitivity analyses controlled for same day ambient ozone, particulate matter <2.5 microns, and relative humidity and, separately, explored race groups without ethnicity and different diagnostic code groupings.

Results: Children ages 0–4 years had increased risk of emergency department visits with increased Tmax on lag days 0, 1, and 3. The association was strongest on lag day 0, when an increase in Tmax of 13 °F conferred an excess risk of 2.6% (95% confidence interval [CI]: 2.2–3.0). Stratifying by age, we observed significant positive associations for same-day exposures, for 1–4 year olds. Children less than 1 year of age showed a significant positive association with Tmax only on lag day 3. The race/ethnicity stratified analysis revealed a similar lag pattern for all subgroups. The diagnostic group analysis showed percent excess risk for heat-specific diagnoses (16.6% [95% CI: 3.0–31.9]); general symptoms (10.1% [95% CI: 8.2–11.9]); infectious (4.9% [95% CI: 3.9–5.9]); and injury (5.1% [95% CI: 3.8–6.4]) diagnoses.

Conclusion: We found a significant risk of ED visits in young children with elevated Tmax. Risk patterns vary based on age with infants showing delayed risk and toddlers and preschoolers with same day risk. In addition, the finding of increased risk of injury associated with higher temperatures is novel. Altogether, these findings suggest a need for a tailored

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public health response, such as different messages to caregivers of different age children, to protect children from the effects of heat. Next steps include examining specific subcategories of diagnoses to develop protective strategies and better anticipate the needs of population health in future scenarios of climate change.

Introduction

High outdoor temperatures create a significant public health burden even in highly industrialized countries,[1] and climate change is expected to worsen these health impacts.[2] To date, the relationship between heat and mortality[3–6] and morbidity[1] has been demonstrated across multiple municipalities and regions throughout the US, with highest sensitivity among elderly, working, or young populations, depending on the outcomes examined and types of temperature metrics (e.g. continuous temperature versus heat wave events) used.[7–10] Among young populations, effects seen in 0–4 year olds are often greater than older age groups.[11] However, children under 5 years of age are typically categorized as a single group,[12] with some literature indicating that infants (children under 1 year of age) may have greater risk of adverse health effects from heat.[3,13] Children under age five are highly heterogeneous and include several American Academy of Pediatrics defined age groups, including newborn, infant, toddler, and preschooler.[14] Physiologic and developmental variation among children aged less than 5 years could indicate different risks, and thus, different public health actions needed to protect their health.

Climate change is predicted to increase temperature variability and to break current temperature records. Furthermore, the majority of the world's population now lives in urban settings where heat risk is increased due to the urban heat island effect.[15] Given the increased vulnerability of young children, poorly explored heterogeneity within the youngest age group, and worsening exposure risk, particularly in urban settings, the aim of this study was to better characterize the associations between temperature and specific health effects among young children aged 0–4 years and to examine the variability of health effects within this age group in the urban setting of New York City.

Methods

Health outcome data

The health data included emergency department (ED) visits (outpatient) (all-cause diagnostic codes) from 2005 to 2011 (May 1st–September 30th) for children aged 0–4 years living in NYC, obtained from New York City Statewide Planning and Research Cooperative System (SPARCS). SPARCS is a comprehensive New York statewide all-payer data set of hospitalization and ED visits. The system was established in 1979 as a health-care industry and government collaboration. Each record in our data set represented a single ED visit.

Age in years, sex, and race/ethnicity were extracted along with health data from SPARCS records. Race and ethnicity are coded separately, and we combined the two variables into the following groups using SPARCS terminology: Spanish/Hispanic origin (SHO); black (non-SHO); white (non-SHO); other (non-SHO), which included Asian, Native American, Pacific Islander, and other; or unknown. Race and ethnicity classifications are primarily self-reported and are social constructs rather than physiologic classifications. We chose to include them as race and ethnicity are significant for health disparities in the USA and important markers of individuals' lived experiences, relating potentially to multiple social determinants of health such as the experience of racism and healthcare access.

Diagnostic groups

Using principal diagnostic codes (those assigned after health provider assessments and diagnostic tests, in contrast to intake/triage chief complaint), we classified International Classification of Diseases, Ninth Revision (ICD-9) codes into groups according to existing literature on childhood heat morbidity[9,12] and the proportional distribution of ICD-9 codes in our own data set. The following six groups were identified: general symptoms (ICD-9 code 780); injury (800–904, 910–929, 950–959); respiratory illness (460–519, 786); viral and ear infections (070–079, 382); heat-related illness (276, 992); and digestion-related illness (564, 787). Although there are over 600 ICD-9 codes reported across all ED events, these six groups of approximately 200 codes capture greater than 75% of cases.

Environmental exposure data

We averaged daily temperature data of the four meteorological stations in the NYC area (JFK International Airport, LaGuardia Airport, Central Park, Newark International Airport) from the NOAA National Climatic Data Center (NCDC) for mean temperature (Tavg), minimum temperature (Tmin), and maximum temperature (Tmax). We calculated relative humidity (RH) from Tavg and dew point temperature using the standard NOAA equation. Average heat index (HI), or apparent temperature, was calculated from Tavg and RH using the National Weather Service's Heat Index formula.[16] To enable adjustment for potential confounding by co-pollutant exposures in our sensitivity analyses, fine particulate matter ($PM_{2.5}$) and ozone (O_3) daily time series were constructed using the average of scaled daily values, to account for between-site differences in means and variances in regulatory monitoring data, as reported previously[17] and as in Schwartz.[18]

Statistical analysis

We used a case-crossover approach, an established method for studying temperature morbidity.[19–23] By comparing

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