What’s Heat Wave and How to Define it?

Heat waves are extreme weather events that are major contributors of heat-related deaths, typically conceptualized as periods of sustained extremely high temperature. In July 1995, a record-setting heat wave in Chicago resulted in at least 700 excess deaths. In August 2003, Europe experienced an unprecedented heat wave which led to at least 30,000 excess deaths in Europe and more than 14,000 in France alone.

Effects of high temperature and heat wave on human health have attracted growing attention because of observed increases in the frequency of extreme weather events worldwide over the past decades, however, our ability to quantify the health impacts of heat wave remains difficult because of the lack of a standard definition of heat wave.

Using Logic Regression to Identify Adverse Health Effects of Heat Waves

In many previous heat wave studies, we only relate the main effects (X1, X2, . . . , Xk) to the response, while interaction (and, or, not) is usually ignored or kept simple. Logic regression (LR) is an adaptive regression method that attempts to construct predictors as Boolean combinations of binary covariates.

For example, consider the following 4 binary temperature indicators:

- TMX98_lag0 = Today’s temperature is above the 98%
- TMX98_lag1 = Yesterday’s temperature is above the 98%
- TMX98_lag2 = Two-days ago, temperature is above the 98%
- TMX98_lag3 = Three-days ago, temperature is above the 98%

A simple heat wave definition may be TMX98_lag0 and TMX98_lag1 and TMX98_lag2, which describes a period of 3-consecutive days with high temperature.

Application to a Time-Series Analysis of Emergency Department Visits in Atlanta, 1993 to 2012.

Logic regression tree is interpreted from the bottom (leaves) upwards to the top (knot). Each tree presented the Boolean combination that describes the heat wave.

Relative risk (RR) estimates and 95% confidence interval (CI) for the heat wave effect on selected emergency department (ED) visits were from the quasi-Poisson regression model adjusted for the covariates.

Table 4. Summarized results for selected ED visit outcomes in Atlanta, Georgia, 1993–2012

Table 2. Summarized simulation results of the performance of logic regression in Detecting the Structure of Heat Wave

Conclusions

- From our 20-year time-series analysis, we found the excess heat effect exists significantly in Heat-Related Disease, Acute Renal Failure and All Renal Diseases, Intestinal Infections and Fluid and Electrolyte Imbalance.
- From the simulation results, we found performance of the proposed method was better when the relative risk (RR) is high (1.05 vs. 1.01) or the sample size is large. Otherwise, it may get trapped in the local minimum and detect the subset of the true exposure. The different Exposure (Exp) will also influence the performance.