Too Hot!
An Epidemiological Investigation of Weather-Related Mortality in India

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Abstract

Background
Most environmental epidemiological studies are conducted in high-income settings. The association between ambient temperature and mortality has been studied worldwide, especially in developed countries. However, more research on the topic is necessary, particularly in India, given the limited evidence on the relationship between temperature and health in this country. The average global temperature is increasing, and it is estimated that it will go up further. The factors affecting vulnerability to heat-related mortality are not well studied. Therefore, identifying high-risk population subgroups is of particular importance given the rising temperature in India.

Objectives
This research aimed to investigate the association of daily mean temperature and rainfall with daily deaths (Paper I), examine the relationship of hot and cold days with total and cause-specific mortality (Paper II), assess the effects of heat and cold on daily mortality among different socio-demographic groups (Paper III) and estimate the effect of maximum temperature on years of life lost (Paper IV).

Methods
The Vadu Health and Demographic Surveillance System (HDSS) monitors daily deaths, births, in-out migration and other demographic trends in 22 villages from two administrative blocks in the rural Pune district of Maharashtra state, in western India. Daily deaths from Vadu HDSS and daily weather data (temperature and rainfall) from the Indian Meteorological Department were collected from 2003 through 2013. Verbal autopsy data were used to define causes of death and classified into four groups: non-infectious diseases, infectious diseases, external causes and unspecified causes of death. Socio-demographic groups were based on education, occupation, house type and land ownership. In all papers, time series regression models were applied as the basic approach; additionally, in Paper III, a case-crossover design and, in Paper IV, a distributed lag non-linear model (DLNM) were used.

Results
There was a significant association between daily temperature and mortality. Younger age groups (0-4 years) reported higher risk of mortality due to high and low temperature and heavy rainfall. In the working age group (20-59 years), mortality was significantly associated only with high temperature. Mortality due to non-infectious diseases was higher on hot days (> 39 °C), while mortality from infectious diseases and from external causes was not associated with hot or cold days. A higher heat-related total mortality was observed among men than in women. Mortality among residents with low education and those whose occupation was farming was associated with daily high temperature. We found a significant impact of high temperature on years of life lost, which confirms our results from the previous research (Papers I-III).

Conclusion
The study findings broadened our knowledge of the health impacts of environmental exposure by providing evidence on the risks related to ambient temperature in a rural population in India. More specifically, the study identified vulnerable population groups (working age groups, those of low education and farmers) in relation to high temperature. The adverse effect of heat on population is preventable if local human and technical capacities for risk communication and promoting adaptive behavior are built. Furthermore, it is necessary to increase residents’ awareness and prevention measures to tackle this public health challenge in rural populations.

Keywords: Temperature, heat and cold, mortality, education, socioeconomic status, occupation, rural population, India.