Heat Wave in Guangdong Province, China: Health impact and vulnerability analysis

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Introduction of Guangdong Province

Guangdong Province

*Location*: South China  
*Area*: 179.8 thousand km$^2$  
*Population*: 104.3 million  
*Climate*: Typical sub-tropical & Humid & monsoon  
*Annual average*  
Temperature: 22.9 $^\circ$C  
Precipitation: 1,777 mm
Climate change

IPCC Fourth Assessment

INCREASE IN MEAN

(a)

PROBABILITY OF OCCURRENCE

PREVIOUS CLIMATE

LES COLD WEATHER

NEW CLIMATE

MORE HOT WEATHER

MORE RECORD HOT WEATHER

COLD  AVERAGE  HOT

Large percentage change in extremes
Heat wave impacts human health

<table>
<thead>
<tr>
<th>Year</th>
<th>Location</th>
<th>Excess Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>1981</td>
<td>Portugal</td>
<td>1906</td>
</tr>
<tr>
<td>1995</td>
<td>Chicago</td>
<td>700</td>
</tr>
<tr>
<td>2003</td>
<td>Europe</td>
<td>20,000</td>
</tr>
<tr>
<td></td>
<td>France</td>
<td>15,000</td>
</tr>
<tr>
<td></td>
<td>Portugal</td>
<td>1,317</td>
</tr>
</tbody>
</table>
|         | Britain        | 2,091         

A Silent killer

~900 extra deaths during heatwave
Trends of heat waves in Guangdong

Heat waves frequency trends in Guangdong, 1975-2010

Heat waves duration trends in Guangdong, 1975-2010

Decade trend of heat wave during the last 60 years in Guangzhou, Guangdong
Trends of heat waves in Guangdong
The current study

Part I: Impact of heat waves on mortality;
Part II: Health vulnerability assessment of to heat waves.
Part I Materials

Data Source

Mortality data
- GDCDC
- Daily mortality data grouped by death cause & ages & gender, 2006-2010

Meteorological data
- GDMC
- Daily mean temperature (Tm) & relative humidity (rh), 2006-2010

Air pollution data
- Website of Environment Protection Bureau
- Daily pollutant concentration of SO₂ & NO₂ & PM₁₀, 2006-2010
Part I Study area

Study sites: Guangzhou, Zhuhai, Nanxiong, Taishan
Part I: Effects of heat waves
Part I Definition

**Heat waves**
More than 2 consecutive days with daily temperature at or above the 95th percentile of the year-round city-specific distribution.

**Timing**
Measured the difference between heat wave day in the warm season and the start of the warm season on 1 May (0 on non-heat wave days).

**Duration**
The heat wave’s length in days. The first day of heat wave was set to 0 corresponding to no accumulated heat effects, 1 on the second day, and so on.

**Intensity**
Measured the difference between the temperature during the heat wave day and the city’s heat threshold (0 on non-heat wave days).

**Main effect**
Defined by the relative risk between the median temperature among heat-wave days versus the 65th percentile of annual temperature distribution for each city.

**Added effect**
The added effect of heat waves is defined as the relative risk due to duration of heat sustained for 2 or more consecutive days, with heat threshold at 95th percentile.
Statistical analysis

We used the following Poisson regression formula

\[
\log \hat{E}[Y_i] = \alpha + \text{NS}(RH_i) + \text{NS}(Time_i) + \text{NS}(Season_i) + \beta^2 \text{DOW}_i + m(h_i) + \nu(i)
\]
## Results

### Estimated heat wave main and added effects on daily mortality

<table>
<thead>
<tr>
<th>City</th>
<th>Lag0 (95%CI)</th>
<th>Lag0-5 (95%CI)</th>
<th>Lag0-10 (95%CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Nanxiong</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main effect</td>
<td>22.3(10.9-48.3)</td>
<td>-15.4(-36.2-12.3)</td>
<td>-15.4(-41.3-22.0)</td>
</tr>
<tr>
<td>Added effect</td>
<td>-5.9(-19.6-10.1)</td>
<td>39.3(0.8-92.4)</td>
<td>17.8(-25.6-86.3)</td>
</tr>
<tr>
<td>Guangzhou</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main effect</td>
<td>13.6(6.1-21.7)</td>
<td>19.9(9.1-31.8)</td>
<td>15.1(2.2-29.6)</td>
</tr>
<tr>
<td>Added effect</td>
<td>4.4(-1.9-11.0)</td>
<td>1.6(-8.7-13.2)</td>
<td>0.5(-13.1-16.2)</td>
</tr>
<tr>
<td>Zhuhai</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main effect</td>
<td>1.0(-10.5-14.0)</td>
<td>-0.5(-16.3-18.2)</td>
<td>1.0(-19.0-25.8)</td>
</tr>
<tr>
<td>Added effect</td>
<td>8.1(3.4-21.1)</td>
<td>0.7(-18.1-24.0)</td>
<td>3.8(-21.7-37.5)</td>
</tr>
<tr>
<td>Taishan</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main effect</td>
<td>26.0(15.2-37.8)</td>
<td>8.7(-4.2-23.4)</td>
<td>-1.5(-15.4-14.6)</td>
</tr>
<tr>
<td>Added effect</td>
<td>-2.9(-10.6-5.4)</td>
<td>13.5(-1.4-31.3)</td>
<td>9.3(-9.3-31.7)</td>
</tr>
<tr>
<td>Overall</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Main effect</td>
<td>15.1(4.6-26.7)</td>
<td>6.6(-3.7-20.5)</td>
<td>4.1(-7.1-16.5)</td>
</tr>
<tr>
<td>Added effect</td>
<td>1.8(-3.4-7.2)</td>
<td>7.6(-1.8-17.9)</td>
<td>4.4(-5.9-15.8)</td>
</tr>
</tbody>
</table>
Results

Main and added effects of heat wave by age, city
Part II: Vulnerability analysis

- Vulnerability basically is responses to risks of environmental hazards, human exposure, and human sensitivity or adaptive capacity on individual or community levels;
- The main purpose of vulnerability assessment is to identify adaptation strategies that are feasible and practical to protect and mitigate the potential risk;
- Adaptation refers to a process, action in a system (household, community, group, sector, region, country) to better cope with, manage or adjust to some changing condition, stress, hazard, risk;
Regional vulnerability to heat waves in Guangdong?
Vulnerability index

- Vulnerability index seeks to provide relative vulnerability levels for countries, regions or communities;
Indicators choice

Vulnerability Index

Sensitivity
- % of population older than 65 years of age
- % of population less than 5 years of age
- % of Immigrant population
- Unemployment rate
- % of population engaged in agricultural
- Infant mortality rate

Exposure
- Annual average temperature growth (1975-2005)
- Number of days with the daily maximum temperature over 35°C (1975-2005)

Adaptive Capacity
- % of people who are Health professionals
- GDP per capita
- % of households with per-capita living area less than 8 square meters
- % of harmless sanitary latrines
- % of illiterate in the population older than 15 years old
Data source

- **Sensitivity and Adaptive Capacity**
  - The fifth census data
  - Guangdong Statistical Yearbook
  - Health Statistics Yearbook of Guangdong

- **Exposure**
  - Monitoring data from Guangdong meteorological center
Weighting of indicators

Vulnerability Index

- Sensitivity
  - % of population older than 65 years of age
  - % of population less than 5 years of age
  - % of Immigrant population
  - Unemployment rate
  - % of population engaged in agricultural
  - Infant mortality rate

- Exposure
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  - GDP per capita
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  - % of illiterate in the population older than 15 years old

Analytic hierarchy process  Principal component analysis
## Weighting of exposure indicators

<table>
<thead>
<tr>
<th>Indicators of Exposure</th>
<th>Weight given by each expert</th>
<th>Average weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of days with the daily maximum temperature over 35°C</td>
<td>A</td>
<td>B</td>
</tr>
<tr>
<td></td>
<td>0.83</td>
<td>0.86</td>
</tr>
</tbody>
</table>
Weighting of social indicators

<table>
<thead>
<tr>
<th>Indicator</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Immigrant population</td>
</tr>
<tr>
<td>% of population engaged in agricultural</td>
</tr>
<tr>
<td>% of population less than 5 years of age</td>
</tr>
<tr>
<td>% of illiterate in the population older than 15 years old</td>
</tr>
<tr>
<td>% of people who are Health professionals</td>
</tr>
<tr>
<td>% of population older than 65 years of age</td>
</tr>
<tr>
<td>GDP per capita</td>
</tr>
<tr>
<td>% of households with per-capita living area less than 8 square meters</td>
</tr>
<tr>
<td>Infant mortality rate</td>
</tr>
<tr>
<td>% of harmless sanitary latrines</td>
</tr>
<tr>
<td>unemployment rate</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Rotated Component Matrix</th>
<th>Weight</th>
</tr>
</thead>
<tbody>
<tr>
<td>% of Immigrant population</td>
<td>0.903</td>
<td>0.169</td>
</tr>
<tr>
<td>% of population engaged in agricultural</td>
<td>0.885</td>
<td>0.282</td>
</tr>
<tr>
<td>% of population less than 5 years of age</td>
<td>0.879</td>
<td>-0.144</td>
</tr>
<tr>
<td>% of illiterate in the population older than 15 years old</td>
<td>0.781</td>
<td>0.323</td>
</tr>
<tr>
<td>% of people who are Health professionals</td>
<td>0.750</td>
<td>-0.113</td>
</tr>
<tr>
<td>% of population older than 65 years of age</td>
<td>0.563</td>
<td>0.441</td>
</tr>
<tr>
<td>GDP per capita</td>
<td>0.494</td>
<td>0.194</td>
</tr>
<tr>
<td>% of households with per-capita living area less than 8 square meters</td>
<td>-0.192</td>
<td>0.822</td>
</tr>
<tr>
<td>Infant mortality rate</td>
<td>0.300</td>
<td>0.694</td>
</tr>
<tr>
<td>% of harmless sanitary latrines</td>
<td>0.575</td>
<td>0.611</td>
</tr>
<tr>
<td>unemployment rate</td>
<td>0.007</td>
<td>-0.079</td>
</tr>
</tbody>
</table>
Developing the index

Vulnerability Index (VI)

\[ VI = EI \times (SI + 1 - AI) / 2 \]
Distribution of Exposure Index

The distribution of Exposure Index to heat waves among 124 counties/districts in Guangdong
Distribution of Social vulnerability

The distribution of Social vulnerability to heat waves among 124 counties/districts in Guangdong
Distribution of overall vulnerability

The distribution of Vulnerability to heat waves among 124 counties/districts in Guangdong
Social-economic status and vulnerability
Conclusions

• Heat wave increased mortality risk in Guangdong;
• Low socioeconomic status regions such as the west, north and east of Guangdong Province are vulnerable regions to heat waves;
• The elderly, females, population with respiratory diseases and population with low SES are vulnerable population.
Recommendations

• Enhancing health impacts assessment of climate change;
• Improving climate change related surveillance system that integrates meteorological data into health data;
• Developing heat wave related early warning system based on health outcomes;
• Involving stakeholders to protect vulnerable population in vulnerable regions;
• Strengthening health risk communication of climate change in the public to improve automotive adaptation behaviors.
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- My colleagues in GDCDC and many others.
Thank you