Modelling the temperature - suicide mortality relation in Japan

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Suicide World Statistics

~1,000,000 deaths worldwide
~10 to 20 times more people attempted suicide (every 40 sec)

Japanese Suicide Statistics (WHO, 2008)

Suicide rates (per 100,000), by gender, Japan, 1950-2006.

Suicide rates (per 100,000), by gender, USA, 1950-2005.

Literature Review: Climate Probably Affects Suicide

<table>
<thead>
<tr>
<th>Found Associations</th>
<th>No Associations</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hippocrates (Deisenhammer 2003; Schory et al. 2003)</td>
<td></td>
</tr>
<tr>
<td>Posidonius and Strabo, Greek philosophers and geographers (Sanderson 1999)</td>
<td></td>
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<tr>
<td>Zhou et al. 1974</td>
<td></td>
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<tr>
<td>Thomas and Kasenvern 1984; Brauer et al. 1986; Lester 1986; Susp and Yen et al. 1987</td>
<td>Dixon and Shulman 1982; Chin 1988</td>
</tr>
<tr>
<td>Suvret et al. 1991; Golembiowski et al. 1992; Trappe and Kugler 1994; Las et al. 1994; Chen and PicChery 1995; Saik 1997; Saik and Gray 1997; Saik and Lester 1999</td>
<td></td>
</tr>
</tbody>
</table>
Literature Review: Seasonality of Suicide (highest rates in late spring)

- Lester 1971; Zung et al. 1974
- Preti and Miotto 2000; Preti 2002; Petridou et al. 2002; Deisenhammer 2003; Deisenhammer et al. 2003; Rock et al. 2003; Partonen et al. 2003a,b; Bridges et al. 2005; Papadopulos et al. 2005; Yip et al. 2006; Konstantinidis et al. 2006; Dixon et al. 2007; Preti et al. 2007; Rocchi et al. 2007

Climatic Factors Affecting Suicide in Japan

- Temperature
- Duration of daylight
- Atmospheric pressure
- Humidity
- Rainfall
- Latitude
- Single location
  - Mie prefecture, Osaka, or Tokyo
- Monthly or yearly data
  - Mie prefecture
- Single year of data
- Effect of seasonal factors on suicide rate is unclear

Temperature-Mortality Relation

Nonlinearity (V-shape)

- Dose-response concept
  - Low dose → beneficial
  - High dose → lethal
  - V-shaped curves
- Threshold approach
  - Death rate increase near extremes (Kalkstein & Davis, 1989)
  - Baseline = MR(minimum)
  - V-shaped curves

Climatic Factors Affecting Suicide: Positive Associations

- Climate and Environment
  - Weather
    - Posidonius and Strabo (Sanderson 1999)
    - Durkheim ([1951] 1997)
- Atmospheric variables
  - Positive Associations
    - Preti et al. 2000; Deisenhammer et al. 2003; Lambert et al. 2003; Partonen et al. 2004a; Nicholls et al. 2006
- Wind
  - Positive Associations
    - Preti and Miotto 2000
- Humidity
  - Positive Associations
    - Preti & Miotto 1998
- Cloudiness and Rainfall
  - Positive Associations
    - Souetre et al. 1987; Maes et al. 1994; Preti & Miotto 1998; Petridou et al. 2002; Lambert et al. 2003; Dixon et al. 2007
- Sunshine
  - Positive Associations
- Temperature
  - Positive Associations
    - Breuer et al. 1986; Lester 1986; Souetre et al. 1987; Maes et al. 1994; Salib 1997; Salib and Gray 1997; Preti and Miotto 2000; Deisenhammer et al. 2003; Page et al. 2007
- Hot Temperature
  - Positive Associations
Studies to Analyze the Temperature-Suicide Mortality Relation

- Mental health professionals
  - Individual case studies
  - Profile analysis
  - Simple correlation analysis
- Epidemiologists
  - Descriptive analysis
  - Time-series studies
  - Case-crossover studies
- Geographer-climatologists
  - Spatial analysis
  - Composite and multi-scale analysis

Specific Issues of Time-Series

- Confounding
- Shape of the function
- Lag
- Temporal autocorrelation
- Overdispersion

Time-Series Regression Models

- Parametric:
  - Linear
  - Log-linear
  - Poisson regression models
  - Generalized Linear Models (GLM)
- Nonparametric:
  - Smoothing splines
  - LOESS
- Semi-parametric:
  - Semi-parametric Poisson regression models
  - Generalized Additive Models (GAM)

Objectives

- Develop an appropriate model enabling optimum prediction of the daily fluctuations in suicide mortality
- Describe the pattern of the relation between temperature and suicide mortality, using Generalized Additive Models (GAM)

Data

- Suicide mortality data (Ministry of Health and Welfare of Japan)
  - 1972-1995
  - 47 prefectures of Japan
  - Include gender, date of birth and area codes
- Population data (Prime Minister’s Office of Japan)
  - 1972-1995
  - 47 prefectures of Japan
  - Include data stratified by gender, age, year and area code
- Meteorological data (Japan Meteorological Agency - JMA)
  - 1972-1995
  - 47 prefectures of Japan
  - Include computerized daily meteorological data
### Region-Specific Study

<table>
<thead>
<tr>
<th>Study period</th>
<th>Number of observations</th>
</tr>
</thead>
<tbody>
<tr>
<td>1972-95</td>
<td>8766</td>
</tr>
</tbody>
</table>

#### Regions
- Hokkaido
- Tohoku
- Kanto
- Chubu
- Kinki
- Chugoku
- Shikoku
- Kyushu
- Okinawa*

### Suicide Death Counts, Means, and MRs

<table>
<thead>
<tr>
<th>Regions</th>
<th>Deaths</th>
<th>Mean</th>
<th>MR</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hokkaido</td>
<td>24,489</td>
<td>2.79</td>
<td>0.50</td>
</tr>
<tr>
<td>Tohoku</td>
<td>47,548</td>
<td>5.42</td>
<td>0.57</td>
</tr>
<tr>
<td>Kanto</td>
<td>134,284</td>
<td>15.32</td>
<td>0.43</td>
</tr>
<tr>
<td>Chubu</td>
<td>87,744</td>
<td>10.01</td>
<td>0.49</td>
</tr>
<tr>
<td>Kinki</td>
<td>89,250</td>
<td>10.18</td>
<td>0.47</td>
</tr>
<tr>
<td>Chugoku</td>
<td>34,803</td>
<td>3.97</td>
<td>0.52</td>
</tr>
<tr>
<td>Shikoku</td>
<td>19,902</td>
<td>2.27</td>
<td>0.55</td>
</tr>
<tr>
<td>Kyushu</td>
<td>59,383</td>
<td>6.77</td>
<td>0.52</td>
</tr>
<tr>
<td>Okinawa*</td>
<td>4,547</td>
<td>0.54</td>
<td>0.47</td>
</tr>
</tbody>
</table>

### Time-Series Regression Model

- **Poisson Regression Model**
  - Control for confounding factors
  - Smooth function of time \( f(t) \)

#### Generalized Additive Model (GAM)

- \( Y \sim \text{Poisson}(\mu) \), \( \text{var}(Y) = \phi \mu \)

- \( \log(\mu) = X^\prime \theta + f(t) + s_1(x_1) + s_2(x_2) + \ldots \)

  - \( \log \) - link function
  - \( \mu \) - expected value of suicide mortality at time \( t \)
  - \( X \) - \( p \times 1 \) row in the parametric model matrix
  - \( \theta \) - vector of parameters
  - \( s \) - smooth functions of the covariates \( x \) (temp, rhum, sun, \ldots)

#### Model Choice

- **Smooth function**
  - Natural cubic spline
  - Smoothing spline
  - Penalized spline

- **Amount of smoothness for the function**
  - Fixed degrees of freedom
  - AIC
  - BIC
  - ACF/PACF
  - UBRE/GCV
Modelling Framework

Poisson Regression Model + Confounding factors → GAM

Smooth function $f$ → Penalized spline

Degree of smoothness ($d_s$) → AIC, PACF

- Oversmoothing → confounding bias
- Undersmoothing → too much temporal variability

GAM model

\[
\log(E(\text{suicide}_i)) = f_1(\text{time}_i, d_s=264) + f_2(\text{mxt}_i, d_s=5) + \\
+f_3(\text{pst}_i, d_s=5) + f_4(\text{rhum}_i, d_s=5) + \\
+f_5(\text{sun}_i, d_s=5) + f_6(\text{light}_i, d_s=4) + \\
\{\text{dow}_i\} + 1(\text{hol}_i)
\]

- $f_1$,...,$f_6$ penalized spline functions; $d_s$ - degrees of smoothness
- mxt, pst, rhum, sun, light - daily maximum temperatures, atmospheric pressure, relative humidity, sunshine duration
- dow, hol - day of the week, holidays

Check for Autocorrelation

Dispersion Parameter

<table>
<thead>
<tr>
<th>Hokkaido</th>
<th>Tohoku</th>
<th>Kanto</th>
<th>Chubu</th>
<th>Honshu</th>
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<th>Kyushu</th>
<th>Okinawa</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.23</td>
<td>1.08</td>
<td>1.08</td>
<td>1.06</td>
<td>1.07</td>
<td>1.07</td>
<td>1.09</td>
<td>1.05</td>
</tr>
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Check for Autocorrelation (continue)
Summary

- Short-term effect of temperatures on suicide mortality: when temperature increased suicide mortality increased on the same day.
- When temperature increased the suicide mortality increased only for violent method.
- Inclusion of the sunshine duration or relative humidity into the model did not affect the model fit.
- The increase in suicide mortality was also observed when atmospheric pressure increased.
Conclusion:

This study suggests that an increase in temperature has short-term effect on suicide mortality in Japan and that the new comprehensive national strategies for suicide prevention should be considered.

“July 21, 2004 – Temperature in Otemachi (Tokyo) shot up to 39.5, the highest on record”
(The Japan Times: Sept. 22, 2004)