Daily Rhythms 1: Population Denominators and Spatio-Temporal Crime Hotspots

Manchester Metropolitan University Crime & Well-Being Big Data Centre

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Contents

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Population measures

1. Residential Population
2. Workplace Population (Malleson & Andresen, 2016)
3. Ambient Population (Mburu & Helbich, 2016; Andresen, 2011; Bogomolov et al., 2014)

Research Questions
Q1. Do these population estimates capture the daily rhythms of the city?
Q2. Do they represent the population-at-risk?
Our Greater Manchester data

- **Mobile Phone Origin Destination (MPOD)** matrices from Transportation of Greater Manchester (TfGM)
  - Average number of persons travelling per trip from Origin A to Destination B in different time bins ($T_0$, $T_1$, ..., $T_N$)
  - Each trip assigned with a flag to represent final Destination (1- YES, 0- No)

- **Crime Data** from Greater Manchester Police (GMP)
  - Attributes: Crime records with spatial coordinates and time-stamps / (non domestic) violent crime
The spatial patterning of violent crime counts
Conventional correlation analysis (daily population measure)

<table>
<thead>
<tr>
<th></th>
<th>Residential pop</th>
<th>Workplace pop</th>
</tr>
</thead>
<tbody>
<tr>
<td>Pearson Correlation</td>
<td>.202**</td>
<td>.626**</td>
</tr>
<tr>
<td>Sig. (2-tailed)</td>
<td>.000</td>
<td>.000</td>
</tr>
<tr>
<td>N</td>
<td>1673</td>
<td>1673</td>
</tr>
</tbody>
</table>

**. Correlation significant at 0.01 level (2-tailed).
The temporal patterning of violent crime

[Graph showing the temporal patterning of violent crime with time coverage for different categories: Workplace (9to5), Resident (5to9), Exposed (24 hours), Ambient (24 hours).]
Ambient (total) population

• Based on the incremental flows of the residential population in different time bins ($T_0$, $T_1$, ..., $T_N$)!

• Assuming the ambient population to be equivalent to residential population at $T_0$ (midnight)
  - $\text{Amb}_{-}\text{pop}_{-}T_0 = \text{Resid}_{-}\text{pop} + \text{Inflows}_{-}T_0 - \text{Outflows}_{-}T_0$
  - $\text{Amb}_{-}\text{pop}_{-}T_1 = \text{Amb}_{-}\text{pop}_{-}T_0 + \text{Inflows}_{-}T_1 - \text{Outflows}_{-}T_1$
Exposed (mobile) population

• Based on determining the street based population at different time bins (T₀, T₁,...,Tₙ)!

• This excludes the population who have reached their final destination or have left the area (initial origin) at particular time

• \( \text{Exp}_\text{pop}_\text{T₀} = \text{Inflows}_\text{T₀} + \text{Outflows}_\text{T₀} - \text{Inflows}_\text{T₀}_\text{FD} - \text{Outflows}_\text{T₀}_\text{FO} \)
Time sensitive ambient and exposed populations

T1 = 7 am to 10 am
T2 = 10 am to 16 pm
T3 = 16 pm to 19 pm
T4 = 19 pm to 7 am

Ambient Population
Exposed Population
Time sensitive correlation analysis

T1 = 7 am to 10 am
T2 = 10 am to 16 pm
T3 = 16 pm to 19 pm
T4 = 19 pm to 7 am
Hotspot analysis

- Gi* statistics (Getis-Ord’s Gi*)
- Z-score of Gi* (p-value <0.05) enables identification of high or low value clusters of spatial units.
- Question – to what extent does the method of spatio-temporal clustering impact on the detection of hotspots?
Violent Crime Count and Crime Rate Hotspot Analysis by Different Population Denominators in Different Time Bins
T2 = 10 am to 16 pm

Crime Counts

Hotspots by Workplace Population

Hotspots by Ambient Population

Hotspots by Exposed Population
T4 = 19 pm to 7 am

Crime Counts

Hotspots by Residential Population

Hotspots by Ambient Population

Hotspots by Exposed Population
Conclusion

• The daily rhythms of the city – ambient and exposed populations.
• The exposed (theoretically correct?) population holds a higher correlation with the violent crime than the ambient population across multiple time bins.
• Different population denominators generate markedly different hotspots.
• Population denominators require to be sensitive to crime type.
Questions?

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