Spatial relationships in short-term mortality experience in England 1600-1835

Gill Newton, Cambridge Group for the History of Population and Social Structure
Omran’s Theory of the Western Epidemiological Transition

• Interlinkage between mortality change, pop growth and socioeconomic factors such as urbanisation and the rise of transport networks
• Initial mortality decline socially not medically determined

1. Age of Pestilence and Famine to 1650

2. Age of Receding Pandemics
   a. Early phase 1650 – 1800
   b. Late phase 1800 – 1920

3. Age of Degenerative Diseases 1920 onwards
1. Age of Pestilence and Famine
to 1650

- pop growth cyclical with minute net increments
- CDR >30-50
- ECMR high; IMR up to 200-300
- mortality fluctuates with frequent higher peaks caused by famines and epidemics
- smallpox is a childhood disease
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3. Age of Degenerative Diseases  
   – pop growth falls; $e_0$ reaches 70; infectious diseases replaced by cardiovascular disease/cancer
621 Sample Parishes (5% English parishes)

In BLUE: original 404 parishes
In RED:  217 additional parishes

Major additions:

• Leeds and Birstall
• Liverpool
• London and Middlesex
• Hull
• Sedgley, Staffs
• York

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Looking for spatial relationships in mortality experience

• Are there correlations between annual burial counts in different locations?
• Is there a spatial relationship between pairs of correlated parishes?
• How does this change over time?

To answer these questions we took every possible pair of parishes from our sample and calculated cross-correlations in 50 year periods between 1600 and 1835. Correlated parish pairs were mapped as straight lines joining the centroid of each parish.
Comparing pairs of parishes

- Burial counts subdivided into 50 year time series
- Parishes with mean of <20 burials per annum removed
- Parishes with missing values removed
- 5 year moving averages calculated and subtracted from point value to strip out effect of pop growth
- Cross-correlation calculated for every pair of time series in every period
- At present only lag 0 considered

<table>
<thead>
<tr>
<th>Period</th>
<th>parishes in observation</th>
<th>pairs tested</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600-49</td>
<td>108</td>
<td>5778</td>
</tr>
<tr>
<td>1650-99</td>
<td>128</td>
<td>8128</td>
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<tr>
<td>1700-49</td>
<td>209</td>
<td>21736</td>
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<tr>
<td>1750-99</td>
<td>227</td>
<td>25651</td>
</tr>
<tr>
<td>1800-35</td>
<td>183</td>
<td>16653</td>
</tr>
</tbody>
</table>
Deciding on a significance threshold

- Thousands of pairs were tested in each period
- There is a trade-off between significance threshold and useable number of parish pairs
  
  EITHER more robust, fewer results
  
  OR more results, more noise (false positives)
- By inspection of the resulting cross-correlation, a threshold of ± 0.5 was chosen
- For the shorter 1800-35 period a more stringent threshold of ± 0.6 was used
- We know these thresholds will have produced false positives

<table>
<thead>
<tr>
<th>Period</th>
<th>Parishes in observation</th>
<th>Pairs tested</th>
<th>Pairs with CCF &gt; 0.5 or CCF&gt;0.6 1800-35</th>
<th>% Pairs correlated</th>
</tr>
</thead>
<tbody>
<tr>
<td>1600-49</td>
<td>108</td>
<td>5778</td>
<td>209</td>
<td>3.62</td>
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<td>1.25</td>
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<td>1800-35</td>
<td>183</td>
<td>16653</td>
<td>31</td>
<td>0.19</td>
</tr>
</tbody>
</table>
The changing extent of spatial convergence over time

% pairwise comparisons correlated by period

1600-49 1650-99 1700-49 1750-99 1800-35
Pairs of parishes with correlated annual burials 1600-49
Correlations in the North 1600-49
River connections: Howden, Yorkshire on John Speed’s Map of 1610

- to York
- to Leeds
- to Hull and sea
- to Gainsborough and Nottingham
Pairwise annual burials correlations 1650-99
Pairwise annual burials correlations 1700-49
Pairwise annual burials correlations 1750-99
Pairwise annual burials correlations 1800-35
### Top 10 interlinked parishes by period

<table>
<thead>
<tr>
<th>1600-49</th>
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<th>1750-99</th>
<th>1800-35</th>
</tr>
</thead>
<tbody>
<tr>
<td>Norwich</td>
<td>Stratford Bow, Essex</td>
<td>Norwich</td>
<td>Norwich*</td>
<td>Ipswich*</td>
</tr>
<tr>
<td>London</td>
<td>London</td>
<td>Ipswich</td>
<td>Shrewsbury*</td>
<td>Norwich*</td>
</tr>
<tr>
<td>Stratford Bow, Essex</td>
<td>Ipswich</td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Enfield, Middlesex</td>
<td>Norwich</td>
<td></td>
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<tr>
<td>Gravesend, Kent</td>
<td>Woburn, Bedfordshire</td>
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<tr>
<td>Rochdale, Lancashire</td>
<td>New Brentford, Middlesex</td>
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<td></td>
<td></td>
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<tr>
<td>Dalston nr Carlisle</td>
<td>Gravesend, Kent</td>
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<tr>
<td>Lancaster</td>
<td>Reigate, Surrey</td>
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<tr>
<td>Reigate, Surrey</td>
<td>Woodbridge, Suffolk</td>
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<tr>
<td>Leeds</td>
<td>Benenden, Kent</td>
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*Correlations restricted to other parishes in same town only*

- Parishes must be correlated with at least 5 others to feature in this table
Conclusion

• Before 1650/1700 we can identify 3 distinct regions of shared mortality experience
  – West of the Pennines
  – Yorkshire
  – The South East
• There is a relationship between economic importance, trading routes and mortality convergence
• But not a simple one since spatial convergence in mortality experience actually decreases over time
• London and other major cities develop idiosyncratic mortality fluctuations, we think because their populations grow sufficient to sustain more pathogens as endemic diseases
• ...Further work
  – considering adult/child burials separately
  – seasonal convergence
  – lagged convergence
  – methods to allow use of smaller parishes/ones with missing values