Spatio-temporal Analysis of Risk Factors for Foot-and-mouth Disease in Tanzania

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Reflections

- FMD is endemic and widely distributed
- One of the major constraints to commercial livestock farming in Tanzania
- Tanzania has adopted PCP philosophy, and now in stage 2
- Aim to fulfill outcome 7 of stage 1 of FMD - PCP
Methodology

• DATA BASE
  – Passive surveillance data Jan 2001- Dece2006
  – 878 clinical cases
  – Location of national parks
  – Human population, distribution and activities
  – Communication networks, and
  – international borders

• SPATIAL ANALYSIS
  – Extraction maps
  – Space time K-function,
  – Space-time permutation models based on scan statistics were calculated to evaluate the spatial distribution, the spatio-temporal interaction and spatio-temporal clustering of the affected villages
Results – temporal clustering

- Variable outbreaks

<table>
<thead>
<tr>
<th>Year</th>
<th>FMD outbreaks</th>
</tr>
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<tbody>
<tr>
<td>2001</td>
<td>52</td>
</tr>
<tr>
<td>2002</td>
<td>62</td>
</tr>
<tr>
<td>2003</td>
<td>160</td>
</tr>
<tr>
<td>2004</td>
<td>410</td>
</tr>
<tr>
<td>2005</td>
<td>59</td>
</tr>
<tr>
<td>2006</td>
<td>135</td>
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</tbody>
</table>
Temporal distribution of FMD outbreaks for the 2001 – 2006 reporting period
**Space-time interaction**

\[ D_0(s,t) = \frac{D(s,t)}{K(t)K(s)} \]

Excess risk or proportional increase in number of cases attributable to the time-space interaction

- Contagiousness in Space
- Deficiencies in movements control

- Contagiousness in Time
  - Long infectious periods (sources of agent)
Space-time interaction
The spatio-temporal interaction

- Significant (P ≤ 0.01)
- FMD affected villages were clustered at 80-100km in 2001 and 2002, but 2001 had a larger temporal component (50 days)
- In 2003 there was an increase of the clustering in both dimensions which would indicate an increase of the infectiousness in time (65 days) and space (200 km)
- 2004 limited clustering ≈ 2001
- 2005 intense clustering at shorter distances (30 km) and time (5 days)
- 2006
Spatio-temporal clustering
Spatio-temporal clustering

• Three statistically significant clusters
  i. From 08/09/2003 to 11/01/2004; affecting 47 villages (RR = 7.97; $P \leq 0.001$)
  ii. From 19/01/2004 to 28/03/2004 affecting 99 villages (RR = 2.76; $P \leq 0.01$)
  iii. From 10/05/2004 to 05/09/2004 affecting 86 villages (RR = 2.72; $P \leq 0.01$)

• The spatio-temporal clusters were consecutive in time
Spatial distribution

• Two distinct spatial patterns were identified
  – Pattern I. **Endemic** – occurred in 2001, 2002, and 2005; and
  – Pattern II. **Epidemic** – occurred in 2003, 2004 and 2006
**Spatial pattern I (Endemic phase)**

- High risk areas concentrated along the international borders
- The distribution of the high risk areas was limited in space, e.g. Tunduma (Tanzania – Zambia border) and Arusha (Tanzania – Kenya border)
Spatial pattern II (epidemic phase)

• Pattern II, Occurred 2003, 2004 and 2006. High risk areas were more expansive
• High risk zone expanded towards the north and the central parts
• The concentration was more important along the main communication lines
• Dar es Salaam & Coast region – consistently at high risk
• The Southern regions remained in general as low risk area
Risk factors

• Risk factors identified
  – Distance to the main roads (risk was reduced with increased distance ≈ 10Km),
  – Distance to the railway lines
    • Weak relationship as compared to roads
  – Distance to the international borders
  – human population density and
  – Distance to the national park
Odds ratios of the risk factors
## Odds ratios of the risk factors

<table>
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<tr>
<th>RF</th>
<th>Year</th>
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<tbody>
<tr>
<td></td>
<td>2001</td>
<td>2002</td>
<td>2003</td>
<td>2004</td>
<td>2005</td>
<td>2006</td>
</tr>
<tr>
<td>N Park</td>
<td>0.84 (0.73-0.97)*</td>
<td>1.00 (0.90-1.11)</td>
<td>0.93 (0.85-0.99)*</td>
<td>1.08 (1.03-1.13)*</td>
<td>1.04 (0.96-1.13)</td>
<td>1.04 (0.96-1.12)</td>
</tr>
<tr>
<td>Road</td>
<td>0.75 (0.59-0.91)*</td>
<td>0.73 (0.56-0.91)*</td>
<td>0.74 (0.63-0.85)*</td>
<td>0.83 (0.76-0.92)*</td>
<td>0.74 (0.59-0.89)*</td>
<td>0.81 (0.71-0.92)*</td>
</tr>
<tr>
<td>Train rail</td>
<td>0.99 (0.95-1.03)</td>
<td><strong>0.92 (0.87-0.97)</strong>*</td>
<td>0.98 (0.95-1.01)</td>
<td><strong>0.94 (0.91-0.96)</strong>*</td>
<td>0.97 (0.93-1.02)</td>
<td><strong>0.94 (0.91-0.98)</strong>*</td>
</tr>
<tr>
<td>Border</td>
<td><strong>0.93 (0.88-0.97)</strong>*</td>
<td><strong>0.96 (0.93-0.99)</strong>*</td>
<td>0.98 (0.96-1.00)</td>
<td>0.99 (0.98-1.01)</td>
<td><strong>0.94 (0.90-0.97)</strong>*</td>
<td><strong>0.96 (0.94-0.99)</strong>*</td>
</tr>
<tr>
<td>Human Popula</td>
<td>1.03 (1.00-1.07)</td>
<td><strong>1.03 (1.01-1.07)</strong>*</td>
<td>1.02 (1.00-1.04)</td>
<td><strong>1.14 (1.09-1.19)</strong>*</td>
<td>0.98 (0.92-1.02)</td>
<td><strong>1.09 (1.05-1.14)</strong>*</td>
</tr>
</tbody>
</table>
Conclusion

• Results confirm the heterogeneity of FMDV transmission in Tanzania;
• FMD occurrence in Tanzania is more related to animal movement and human activities via communication networks than trans-boundary movements or contact with wildlife;
• Southern regions are generally low risk areas and may be a potential FMD free zone if appropriate control measures are put in place;
• FMD PCP could therefore target these areas
Thank you very much!

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