Microspatial Analysis of Rape

A spatiotemporal analysis of rape in Charlotte-Mecklenburg, NC
Charlotte, NC

• A rapidly growing city in North Carolina

• Population in
  – 2000: 659,454
  – 2007: 855,127
  – Growth: 29.7% in seven years

• From 2000 to 2003 (mid-point of the study)
  – Male population increased by 19%
  – Female population increased by 18.2%
  – Females make up 51% of the 2003 population
Rape in Charlotte

• From 2000 through 2006 there were 2070 rapes reported to the CMPD:

Rape Clearance 2000 - 2006

- Exceptionally Cleared: 47.29%
- Open: 33.43%
- Cleared by Arrest: 19.23%
Robbery in Charlotte

• From 2000 through 2006 there were 20,568 robberies reported to the CMPD
A check to confirm clustering

FIRST ORDER SPATIAL ANALYSIS
Overlay is a half-mile quadrat clipped to the base map.
SECOND ORDER SPATIAL CLUSTER ANALYSIS

Indentifying the Nearest Neighbor Hierarchical Hot Spots
Spatial Cluster

• A statistically improbable excess of incidents in geographic space
• Differs in important respects from the geographic variation expected in the absence of the spatial processes that are being investigated
NNH Parameters
Half-mile search radius
25 rapes for inclusion
<table>
<thead>
<tr>
<th>Cluster</th>
<th>Area</th>
<th>Rapes</th>
<th>Density</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>0.226</td>
<td>85</td>
<td>376.74</td>
</tr>
<tr>
<td>2</td>
<td>0.409</td>
<td>46</td>
<td>112.57</td>
</tr>
<tr>
<td>3</td>
<td>0.318</td>
<td>41</td>
<td>128.75</td>
</tr>
<tr>
<td>4</td>
<td>0.320</td>
<td>39</td>
<td>121.87</td>
</tr>
<tr>
<td>5</td>
<td>0.251</td>
<td>36</td>
<td>143.52</td>
</tr>
<tr>
<td>6</td>
<td>0.261</td>
<td>34</td>
<td>130.09</td>
</tr>
<tr>
<td>7</td>
<td>0.232</td>
<td>33</td>
<td>141.96</td>
</tr>
<tr>
<td>8</td>
<td>0.211</td>
<td>32</td>
<td>151.64</td>
</tr>
<tr>
<td>9</td>
<td>0.205</td>
<td>31</td>
<td>150.86</td>
</tr>
<tr>
<td>10</td>
<td>0.312</td>
<td>27</td>
<td>86.44</td>
</tr>
<tr>
<td>11</td>
<td>0.208</td>
<td>31</td>
<td>149.01</td>
</tr>
<tr>
<td>12</td>
<td>0.412</td>
<td>27</td>
<td>65.51</td>
</tr>
<tr>
<td>13</td>
<td>0.235</td>
<td>27</td>
<td>114.99</td>
</tr>
<tr>
<td>Total</td>
<td>3.6</td>
<td>489</td>
<td>135.8</td>
</tr>
</tbody>
</table>

**Hot Spot Rape Concentration Index = 35.8**

23.6% of the rapes occur in less than 1% of the area (0.7%)
Conclusion

- Rape shows spatial clustering over the 7 year period
- Rapes cluster in 13 specific areas of the city
- These hot spots account for almost a quarter of all the rapes in an area of less than 1% of the total region
Examining the temporal pattern of citywide rapes

TEMPORAL ANALYSIS
Hour of the Day

Time Rape Reported to the Police

Frequency

Hour
Daily Pattern

Day of the Week

Frequency

Day

SUN, MON, TUE, WED, THU, FRI, SAT
Weekend Hourly Patterns

Note:
Scale varies on the Ordinate
Day-by-Clearance Status

Note:
Scale varies on the Ordinate
Examining the temporal pattern in the hot spots

TEMPORAL ANALYSIS OF HOT SPOTS
Hour Rapes Reported to Police

Hot Spot Rapes by the Hour

![Graph showing the frequency of rapes reported to police by hour of the day. The graph highlights certain hours with higher frequency.]
Hot Spot Rapes: Day of Week

Day of the Week

Frequency

SUN  MON  TUE  WED  THU  FRI  SAT
Downtown Hourly Pattern

Hour of the Day

Frequency

Hour

Midnight 2 4 6 8 10 12 14 16 18 20 22 24

0 2 4 6 8
Downtown: Day of the Week

Day of the Week

Day

Frequency

SUN  MON  TUE  WED  THU  FRI  SAT
Conclusion

• Overall, the temporal pattern is more diffuse
• Generally, the fewest rapes are reported in the early morning hours (5-7 AM)
• There are two spikes: one around mid-day, early afternoon, and the other around 10 PM
• On weekends, there is a pattern of late night, early morning reports (2-3 AM)
Jacquez’s k-NN Test & Knox Method

SPACE-TIME INTERACTIONS
K set at 25 based on earlier NNH hot spot analysis

JACQUEZ’S NEAREST NEIGHBOR TEST
Jacquez’s k-Nearest Neighbor

Combined P-value:

Statistical Distance Test statistic = 18.554479
Number of Monte Carlo simulations = 999
P-value from Monte Carlo simulations = 0.00100

Bonferroni P-value (J) = 0.02500
Simes P-value (J) = 0.00400

Bonferroni P-value (DJ) = 0.02500
Simes P-value (DJ) = 0.02500
Conclusion

• There is likely to be space-time interaction out to at least $2^d$-order nearest neighbor
• The behavior of the statistic is erratic, probably owing to the relative rare nature of rape incidents
• Try another space-time interaction method
Parameters set a 2640 feet and 3 days

KNOX METHOD
Setting Knox Parameters

- 50% of rapists JTC within 0.5 miles
- Marauder patterns: most rapes within .5 miles of one another
- Temporal patterns vary from 3 days to 3 weeks
- Check by varying time, hold distance constant
- Check by varying distance, hold time constant
Distance Constant: 2640 feet (.5 mi)
Time Constant: 3 days

- Knox Stat
- P-value
- CritP

Miles vs. Knox Stat and P-value for different conditions.
<table>
<thead>
<tr>
<th>Space</th>
<th>Far (&gt;0.5)</th>
<th>Close</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far (&gt;3 d.)</td>
<td>2118971</td>
<td>5943</td>
<td></td>
</tr>
<tr>
<td>Close</td>
<td>16434</td>
<td></td>
<td>67</td>
</tr>
</tbody>
</table>

Knox: Close
Knox: Close

Probability based on the Chi-Square Test:

Test Statistic = 67  
Expected Test Statistic = 46.31  
P-value from Chi-Square = 0.00251

Monte Carlo simulation method:

Test statistic = 67  
Number of Monte Carlo simulations = 999  
P-value from Monte Carlo simulations = 0.00300
Possible Pairs

\[ Pairs = n(n - 1) / 2 = 2,141,415 \]
<table>
<thead>
<tr>
<th>Knox: Far</th>
<th>Time</th>
</tr>
</thead>
<tbody>
<tr>
<td>Far (&gt;1.5 Mi)</td>
<td>Far (&gt;3 d.)</td>
</tr>
<tr>
<td>Knox</td>
<td>2037895</td>
</tr>
<tr>
<td>Close (&lt;1.5 Mi)</td>
<td>97510</td>
</tr>
</tbody>
</table>
Knox: Far

Probability based on the Chi-Square Test:

Test Statistic                       = 305
Expected Test Statistic              = 274.52
P-value from Chi-Square              = 0.03692

Monte Carlo simulation method:

Test statistic                       = 305
Number of Monte Carlo simulations    = 999
P-value from Monte Carlo simulations = 0.03900
Knox Test: Close/Close

• Warren et al close distance (1.66 miles) by 10 day interval
  – Activity space = 2xr = 3.32 miles diameter

<table>
<thead>
<tr>
<th></th>
<th>Far</th>
<th>Close</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space</td>
<td>2007534</td>
<td>116086</td>
</tr>
<tr>
<td></td>
<td>16752</td>
<td>1043</td>
</tr>
</tbody>
</table>
Knox Test: Close/Close

Probability based on the Chi-Square Test:

- Test Statistic = 1043
- Expected Test Statistic = 973.33
- P-value from Chi-Square = 0.01402

Monte Carlo simulation method:

- Test statistic = 1043
- Number of Monte Carlo simulations = 999
- P-value from Monte Carlo simulations = 0.01200
Close/Close (Warren et al)
SPACE-TIME SIGNATURES

Fig. 9 Spatio-temporal signature of assault
Spatio-temporal Signature of Rape
Charlotte-Mecklenburg

P-value from Monte Carlo Simulation

Time (Days)
Spatio-temporal Signature of Rape

P-value from Monte Carlo Simulations

Time (Days)

0 0.01 0.02 0.03 0.04 0.05 0.06 0.07 0.08 0.09 0.1 0.11 0.12

0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16

0.1 Mi 0.125 Mi 0.167 Mi 0.25 Mi 0.50 Mi 0.75 Mi
1 Mi 1.1 Mi 1.125 Mi 1.25 Mi 1.5 Mi CritP
Summary Conclusions

• There is spatial clustering
• There is some diffuse temporal patterning
• There is space-time interaction of rape incidents
• There are likely to be space-time hot spots identified