LECTURE 1: Exploratory Analysis of Infant Mortality and Birth Defects in an Urban Area
Gerard Rushton, Phd.

LECTURE 2: Investigation of the Contribution of Birth Defects to Infant Mortality in Polk County, Iowa
Diane Krishnamurti, M.S., Iowa Birth Defects Registry
Exploratory Analysis of Infant Mortality and Birth Defects in an Urban Area: Towards a Geographically-Based Public Health Surveillance System

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Diane Krishnamurthi—Iowa Birth Defects Registry
Rajesh Krishnamurthy—Department of Geography
Hu Song—Iowa State Department of Health
Purpose of this Talk

To show how the geographic coding of health events can be the basis for an analysis of the geographic patterns of disease that is superior to any analysis based on choropleth mapping.

1. “Analysis” will mean control of spatial scale and assessment of statistical significance.

2. Results will be compared with those from choropleth mapping.

3. We will conclude with an agenda for geographic research in this area.
Approach

1. Make indirect estimates of infant mortality as a continuous spatial distribution.

2. Why continuous? Because we do not expect infant mortality rates to change abruptly at boundaries of census areas or other administrative areas.

3. Make a continuous spatial distribution of the statistical significance of the rates.
Study Area: Des Moines
Approximate locations of births in Des Moines, 1989–92
Approximate locations of infant deaths in Des Moines, 1989–92
Infant mortality rates for the Zip Code Regions of Des Moines
Infant Mortality Rates for Census Tracts in Des Moines
Infant Mortality Rates for Block Groups in Des Moines
Methodology 2: Spatial Mapping Using a Modifiable Spatial Filter

Use a local operator to make a continuous spatial distribution of infant mortality

**STEPS**

1. Lay regular grid lattice over the area—0.4 mile intervals.

2. At each grid point define a circular grid with radius, successively 0.4, 0.8 and 1.2 miles.

3. Within each circle, count infant deaths and births; compute infant mortality rate and assign to grid location.

4. Using linear interpolation between adjacent grid points, make isoline maps of infant mortality rates for each spatial filter size.
Des Moines with a superimposed uniform grid
Query Menu
Querying a grid location

TransCAD Display Layer Query Select Geography Procedure

Infant Mortality Rate (1989-92)
Search Radius (0.4 m)

Grid ID: 1231
Longitude: -93602000
Latitude: 41574000

Press <Alt>-P to print the contents of this window
Illustration of a 0.4 mile spatial filter
0.6 mile search radius
Infant Mortality Rates: Des Moines, 1989-92: 0.4 mile filter
Infant Mortality Rates in Central Des Moines, 1989-92
Querying a grid location

Infant Mortality Rate (1989-92)
Search Radius (0.4 m)

- Grid ID: 1231
- Longitude: -93602000
- Latitude: 41574000
- Births in 0.4 miles: 60.00
- Deaths in 0.4 miles: 4.00
- IMR (/1000): 66.67
Infant mortality rates: Des Moines, 1989–92: 0.8 mile spatial filter
Infant mortality rates: Des Moines, 1989–92: 1.2 mile spatial filter
Methodology 3: Significance of Rates

1. Let each birth in 1989-92 have an identical probability equal to the county-wide infant mortality rate of 9.2 of becoming an infant death.

2. Generate 1,000 geographical distributions of simulated infant deaths.

3. For each of these maps compute the infant mortality rate at each grid location.

4. Compute the proportion of the simulated rates at each grid location that are smaller than the observed infant mortality rate.

5. Define regions with significantly high infant mortality as areas where a high proportion of the simulated rates are smaller than the observed rate.
Significance of observed infant mortality at a grid location

Significance of observed infant mortality rate at a grid location

percent of simulated infant mortality rates at a grid point that are less than the observed rate at the grid point

Simulated infant mortality rate at the given grid point
donaths/1000 births
Monte Carlo Simulations

1. For each birth, simulate infant death.

2. Let each birth in 1989-92 have an identical probability—equal to the county-wide infant mortality rate of 9.2—of becoming an infant death.

3. 1,000 simulations = 1,000 synthetic maps.

4. Calculate the simulated infant mortality rate in the spatial search radius of each grid point for each of the 1,000 simulations.

5. At each grid point, calculate the relative frequency distribution of the 1,000 simulated infant mortality rates in the spatial search radius of each grid.
Percent of simulated infant mortality rates less than the observed rate for 0.4 mile filter
Statistically significant regions in Central Des Moines
Querying a grid Location

**Infant Mortality Rate (1989-92)**
**Search Radius (0.4 m)**

- **Grid ID**: 1231
- **Longitude**: -93602000
- **Latitude**: 41574000
- **Births in 0.4 miles**: 60.00
- **Deaths in 0.4 miles**: 4.00
- **IMR (/1000)**: 66.67
- **Prop. IMRs < IMRo**: 1.00

Press <Alt>-P to print the contents of this window
Percent of simulated infant mortality rates less than the observed rate for 0.8 mile filter.
Percent of simulated infant mortality rates less than the observed rate for 1.2 mile filter
Simulated pattern of infant mortality rates at 0.4 mile spatial filter, Des Moines, 1989-92
Simulated pattern of infant mortality rates at 0.8 mile spatial filter, Des Moines, 1989-92
Percent of simulated infant mortality rates less than test simulated infant mortality rates for 0.4 mile spatial filter.
Percent of simulated infant mortality rates less than test simulated infant mortality rates for 0.8 mile spatial filter.
Significance of this work

I. A Broad Agenda for Geographic Research

Need to investigate some of the consequences of the availability of geo-coded health records:

To an improved understanding of disease patterns
(Public Health Surveillance)

- provide better analyses of disease patterns;
- analyze relationship between the spatial pattern of different diseases;
- relate the patterns of a disease to the social and economic conditions of areas—for different size areas and different methods of spatial aggregation (remember the modifiable areal unit problem).
Significance of this Work

II. A Targeted Agenda for Geographic Research

1. Improved Methods of Spatial Analysis for Disease Patterns.

- Need to pay as much attention to methods based on geo-coded health records as to area-based information;

- Need to develop methods that incorporate known factors that account for differences in disease rates in a population; i.e. develop better null hypotheses than the common assumption that people at risk have an independent and identical probability of having the disease;

- Need to develop alternative methods for inducing spatial error in geo-coded areas to protect the confidentiality of the records;

- Need to investigate the effects of induced spatial error in geo-coded health data on the results of spatial disease monitoring and surveillance.
Significance of this work

III. Towards a Knowledge-Based, Geographically Focussed, Public Health Surveillance System

Need for routine disease surveillance

Need to encapsulate the logic of interactive spatial analysis in knowledge-based analysis systems to generate routine reports on the geographic patterns of disease in any area.


Need to develop alternative methods for inducing spatial error in geo-coded health records to protect the confidentiality of the records

For example:

- introduce spatial error as a function of the density of the health records: the greater the density, the less distance the record is moved;

- constrain the moving of records so that area-based counts are preserved; e.g. block group counts are accurate

- constrain the moving of records so that distance-based counts are preserved;

- make available spatially filtered rates from accurately located, address-matched records; permit users to select filter sizes, subject to constraints
• move only records for which permission to release have not been given;

• make publicly available the rate of personal permission releases for small areas

• many other possibilities.... e.g. make information available for custom-defined areas; cf. school district data
Conclusions

1. The level of spatial aggregation in investigating the geographical patterns of disease or mortality should be flexible: census units are not logical spatial units for analysis—they should be avoided, if possible.

2. The search for patterns should begin as exploratory spatial analysis.

3. For diseases whose etiology are imperfectly understood, characteristics of individual cases (with identifying characteristics removed to ensure confidentiality) should be incorporated in the database of a G.I.S. so that expert investigators can “walk the street” in a GIS environment, examining the characteristics of cases that occur in close geographic proximity.
Conclusions

4. Exploratory spatial analysis of infant mortality should be routine.

5. Such surveillance should be implemented as “Knowledge-based spatial analysis systems” which should produce reports that include tentative conclusions about the patterns and their relationship to socio-economic data or other spatially distributed information of interest.
Investigation of the Contribution of Birth Defects to Infant Mortality Rates in Polk County, Iowa: A New Approach to Cluster Analysis in Response to a Public Health Concern

Presented by

Diane Krishnamurti, M.S.
Iowa Birth Defects Registry
The University of Iowa
<table>
<thead>
<tr>
<th>City</th>
<th>Infant Mortality Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>Washington, DC</td>
<td>12.92</td>
</tr>
<tr>
<td>Evansville, IN</td>
<td>12.06</td>
</tr>
<tr>
<td><strong>Des Moines, IA</strong></td>
<td><strong>11.97</strong></td>
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<tr>
<td>Syracuse, NY</td>
<td>11.78</td>
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<tr>
<td>San Bernadino, CA</td>
<td>11.70</td>
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<td>Cleveland, OH</td>
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<td>Fort Wayne, IN</td>
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<tr>
<td>Savannah, GA</td>
<td>11.33</td>
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<tr>
<td>Hartford, CT</td>
<td>11.28</td>
</tr>
<tr>
<td>Oklahoma City, OK</td>
<td>11.11</td>
</tr>
</tbody>
</table>

*Source: National Center for Health Statistics 1987*
Participants

* The University of Iowa
  - Department of Preventive Medicine/Environmental Health (Iowa Birth Defects Registry - IBDR)
  - Department of Geography

* The Iowa Department of Public Health

* Local Health Departments
  - City of Des Moines
  - Polk County

* Centers for Disease Control - Atlanta, GA
The objectives of this study were to:

- Identify areas in the City of Des Moines where the infant mortality rate is unusually high.
- Assess potential risk factors which contribute significantly to the high infant mortality rates.
- Evaluate the contribution of specific types of birth defects to the high infant mortality rate in Des Moines.
GIS is an acronym for Geographic Information System.

GIS is a computer system of hardware and software that integrates graphics with databases and allows for display, analysis, and modeling.
Why did we choose the GIS approach to analysis?

"Traditional approach using political boundaries inadequate.

SOLUTION: ADDRESS MATCHING

Problem of unstable rate estimates for small area analysis.

SOLUTION: SPATIAL FILTERS

"Difficult to estimate statistical significance for small number of events and irregular geographic distribution of the birth population.

SOLUTION: MONTE CARLO SIMULATION
Map with grid points at 0.4 mile intervals
Number of infant deaths per specified year

____________________________________  X1000
Number of live births in the same year
One grid point calculated
Two significant areas
Census tract boundaries for areas of interest in Des Moines, 1989-92
Why did we question birth defect rates in Polk County, Iowa?

Des Moines had the third highest infant mortality in the U.S. for city of it’s size.

Of these infant deaths, 26% had birth defects listed as the underlying cause of death.

Birth Defects surveillance data is available from the Iowa Birth Defects Registry.
The Iowa Birth Defects Registry (IBDR)

The IBDR, by authority of the State of Iowa collects information on any child with a birth defect born to an Iowa resident starting with the 1983 birth year.

Information about pregnancy conditions, demographics, and types of defects is collected from the medical record of the hospitals where the child was born, diagnosed, and/or treated.

Information is analyzed by the address of the mother at the time of the child’s birth regardless of where the birth, diagnosis, or treatment occurs.

The IBDR is inclusive of all 99 Iowa counties for the birth years 1983-90.
Why did we choose pathogenetic categories to study birth defects?

Preliminary studies employed conventional anatomic grouping.

Wish to enhance analysis by incorporating many of the things that are currently understood about birth defects.
0.8 mile search radius and at least 40 births
Multiple defects defined by 0.8 mile filter, Des Moines, 1983-90
Significance of Multiple Defects Defined by Monte Carlo Simulations, Des Moines, 1983-90
Correlation graph

Relationship between Infant Mortality Rates and Birth Defect Rates, Des Moines

Infant Mortality Rate (/1000)

Birth Defects Rate (/1000)
Correlation between the defect categories and infant mortality

<table>
<thead>
<tr>
<th>Category</th>
<th>r</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromosomal</td>
<td>-0.0112</td>
</tr>
<tr>
<td>Multiple</td>
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<tr>
<td>Isolated</td>
<td>0.1228</td>
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<td>Malformation</td>
<td>-0.0225</td>
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<tr>
<td>Deformation</td>
<td>-0.0171</td>
</tr>
<tr>
<td>Disruption</td>
<td>-0.0113</td>
</tr>
<tr>
<td>Cardiac\Multiple</td>
<td>-0.0138</td>
</tr>
<tr>
<td>Hemodynamic</td>
<td>0.2130</td>
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</table>
Significance of malformation defects defined by Monte Carlo Simulations, Des Moines, 1983-90
Significance of Deformation Defects Defined by Monte Carlo Simulations, Des Moines, 1983-90
Significance of Disruption Defects Defined by Monte Carlo Simulations, Des Moines, 1983-90
Interpretation of Results

For each analysis, there were 644 grid points.

- The number of significant grid points ranged from 2 to 19.

- Number of significantly high peaks are not greater than 5% expected to be observed by chance.

- No clusters were apparent.

- Distribution pattern of high rates are different for each pathogenetic category which could be due to different risk factors for different categories.

- Only the Hemodynamic Cardiac defect category was positively correlated with infant mortality.
Analysis of rates adjusted by:

a.) maternal age
b.) maternal smoking
c.) marital status
d.) natal age at death
e.) prenatal care
f.) birth weight

Examine types of defects accounting for significantly high rates of multiple defect and isolated defect categories.
Unique Features of this Study

• The Iowa Birth Defects Registry provides data necessary to do comparative analysis.

• GIS provides ability to do precise geographic area analysis.

• Classification of birth defects into pathogenetic categories allows examination of defects according to developmental mechanisms.